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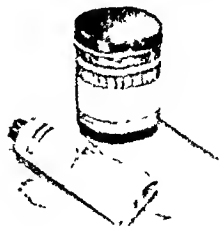
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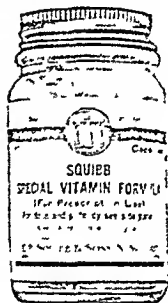


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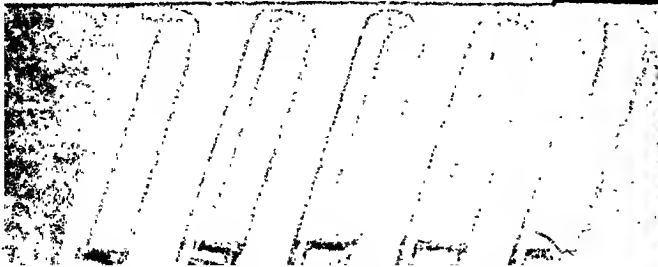
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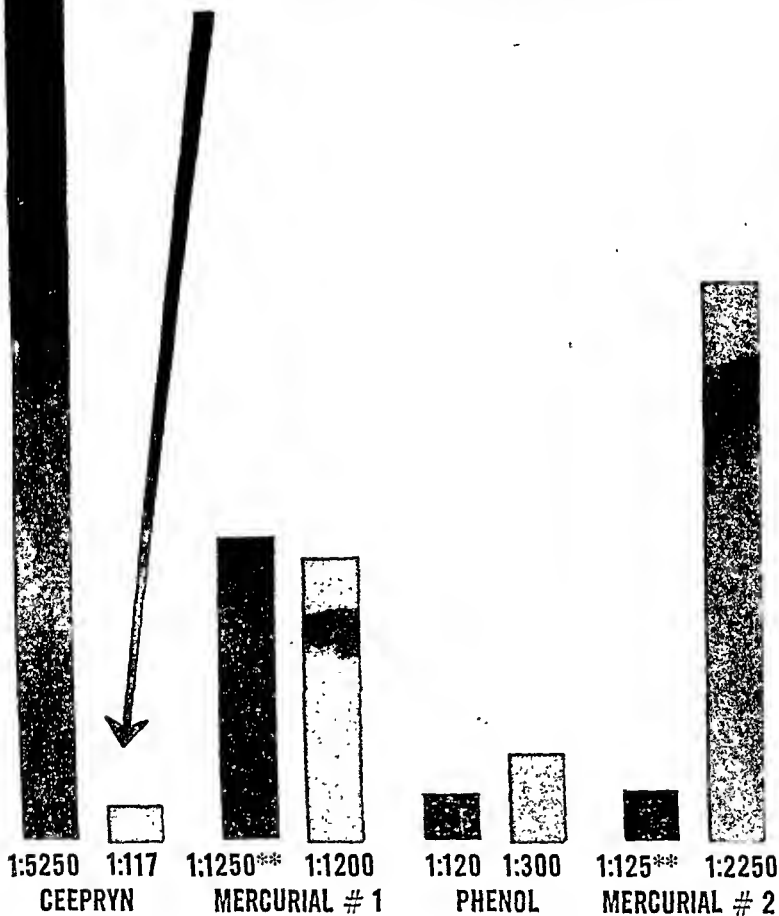
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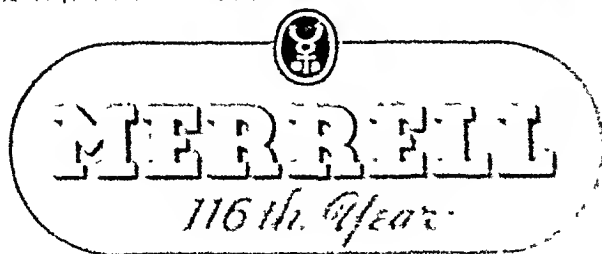
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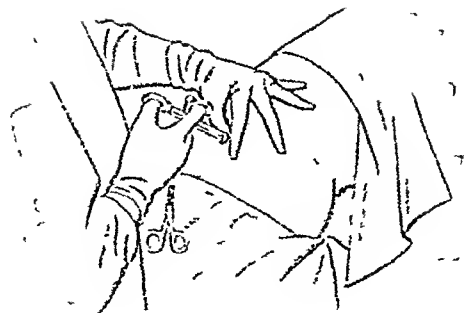
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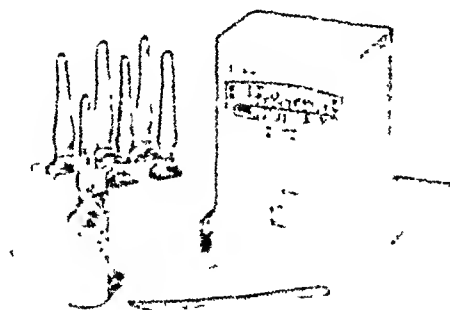
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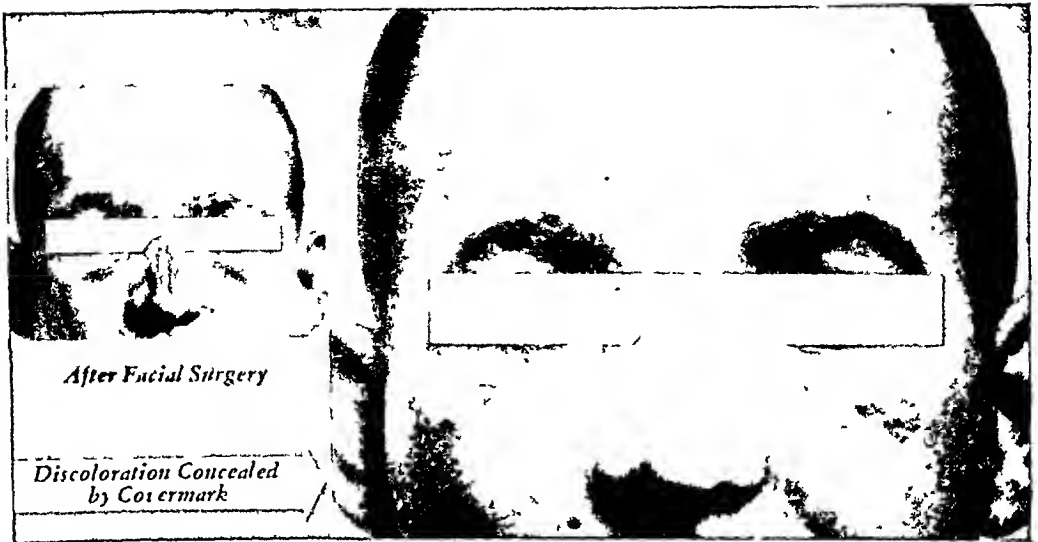
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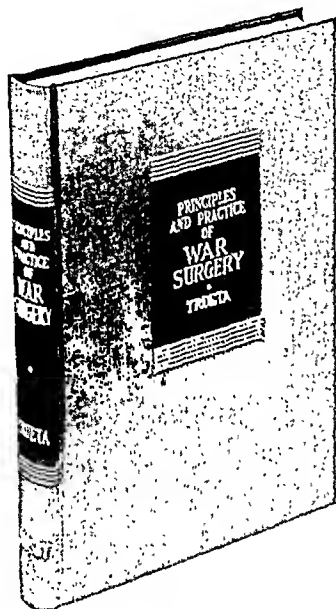
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# SURGERY

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JANUARY, 1944

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## Original Communications

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### Symposium on Plastic Surgery

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#### PLANNING THE RECONSTRUCTION

FERRIS SMITH, M.D., GRAND RAPIDS, MICH.

THE purpose of all reconstructive surgery is the restoration of the part or area to normal or as near to normal as possible. This should include both function and cosmesis. The relative importance of these two objectives varies with the area repaired.

All of the required materials for the repair are available in the patient's body and their use, with two exceptions, cartilage and cornea, are vital to a successful ultimate outcome.

Since the principles of reconstruction of all body surfaces, whether the result of trauma, burns, or congenital defects, are the same and those of the face and neck most exacting in meeting the dual purpose of the effort, this discussion will be devoted to the latter area.

The fundamental principles of obtaining, transferring, and utilizing the various covering and supporting tissues were fully described before World War I, but this isolated literature was not collected, correlated, and appraised for the use of the surgeon. The reconception and employment of methods long since discarded as unsound was a consequence before standards were established. Some procedures of great value were neither generally known nor utilized at all. Many of the cardinal principles had been described for centuries and all had suffered vogues or periods of surgical popularity much as the styles in clothing.

The literature of antiquity relates the extensive practice of tissue transplantation by the Egyptians as far back as 3500 B.C. and reveals that both flap and grafting operations were well known to the Hindu



necessary to prevent it! The essential value of supporting framework was recognized early in this long period of evolution; the anatomic and physiologic principles in providing it have long since been established by observation of trial and error, but these principles are not universally followed today. All types of foreign substances have been advocated and discarded through the centuries, yet new and old ones continue to be introduced. The surgeon frequently refuses to recognize the fate of foreign bodies.

Two important and essential principles of repair were ignored or given scant attention during World War I and have received little more consideration since, except in isolated quarters. I refer to the Z plastic procedure and multiple excision. The former was first described by Denonvilliers,<sup>9</sup> in 1856, and the latter by Morestin,<sup>10</sup> in 1915. Z plastic procedure has been discussed in the literature occasionally since that time, as a method of correcting scar contractures. It has had wide employment in this connection, but numerous other possibilities of its usefulness, both alone and in combination with other principles, appear to be unappreciated.

Davis called attention to the great value and varied uses of multiple excision in 1929.<sup>11</sup> Davis and Kitlowski,<sup>12</sup> in an article published in 1939 dealing with the usefulness of Z plasties for the correction of scar contractures, state, "We find that there are many who do not understand the procedure at all, or realize its usefulness."

"Multiple excision" is the term utilized by Morestin to describe a method of correcting a surface deformity by repeated partial removal and the replacement of the excised portion with normal tissue from the border of the defect. The extent of each removal and replacement is determined by the amount of skin and subcutaneous tissue which can be shifted into the area at each procedure. Repeated procedures of this sort at proper intervals are possible because the skin subsequently returns to its normal tension and elasticity. It is a most important and useful procedure alone or employed in conjunction with other methods of repair.

The experience of the last war stimulated a universal interest in reconstructive surgery, crystallized and standardized many procedures, contributed methods and applications which revolutionized plastic procedure and increased greatly the possibility and variety of useful repair. Among these are the "tubing" of the pedicle of a flap to reduce the possibilities of infection and to permit the safe transference of tissue from a distance.

The enormous demands on the surgeon and his individual lack of experience resulted in the general employment of methods which masked a loss, restored function to a large degree, and left much to be desired from a cosmetic standpoint in many instances. This has continued to

be more or less true. The last quarter century seems to mark another period when certain procedures have enjoyed an almost exclusive vogue regardless of their desirability, while others equally or more important are practically ignored.

The influence of the tubed pedicle on the development of reconstructive surgery during this period has been profound. This, and the availability of rotated flaps of forehead skin for repair of the nose, eyelid, or cheek and the use of free skin grafts has largely dominated the conception and practice of facial reconstruction. This is the triad of procedures for covering surface defects without regard for cosmetic result which evolved so slowly through the centuries.

This has been true particularly since the popularization of "thick, split-skin grafts" by Blair and Brown and the more recent contribution by Padgett of a mechanical means of obtaining them.

I have never seen a skin flap, either pedicled or "free," transplanted from a distant area that matched and blended with its surroundings. It becomes the most prominent and noticeable feature of the face even under the best of circumstances. It is very frequently pigmented or has a glazed, grayish white cast and is necessarily framed in a scar of varying dimensions. Utilization of flaps from the forehead results in a disability which can never be corrected. The results are more functional than cosmetic except in certain rhinoplasties.

These are "procedures of necessity" rather than the "procedures of choice" which their universal use today would seem to indicate. Must we wait again another period of years before we properly evaluate and utilize other methods which produce better results? The surgeon must realize that the end results of pedicled flaps, rotated forehead flaps, and free skin grafts are such that they should never be considered procedures of choice for facial repair even though they must be employed frequently as procedures of immediate necessity. A plan of repair which employs such flaps as the only procedure available immediately should contemplate ultimate replacement of the transplanted skin with normal skin from the vicinity whenever possible.

This general trend of thought and procedure is unilateral thought in respect to the dual responsibility of the surgeon—i.e., to restore to normal, or as near to normal as possible, both function and appearance.

The thinking must become bilateral if the surgeon is to discharge his obligation to the civilian and the soldier. The objective must include restoration of both function and appearance. The latter precludes any plan of repair which adds a single unnecessary scar or foreign tissue to any visible portion of the body.

The surgeon's major thought in planning a reconstruction must thoroughly canvass the possibility of utilizing tissue from the neighborhood, transferred in one of the several ways available, before giving any

consideration to the procedures so universally employed in recent years. The employment of the principles of Z plastic, multiple excision, and interpolated flaps from the vicinity of the defect should have first consideration in the planning of a correction whenever the surgeon may choose his procedure.

I was able recently to contrast typical examples of the current conception of repair, as recorded in recent journals and observed among the patients of my contemporaries, with the results obtained by utilization of Z plasties, multiple excisions, and interpolated flaps from the neighborhood and combinations of these methods through the permission of authors, publishers, and colleagues to use their material.<sup>12</sup> The cases cited then and here are examples of the excellent technical accomplishments of master surgeons. The contrasts in the repaired areas result from differences in planning and choice of methods rather than from differences in surgical skill. A few contrasting results are offered to emphasize our contention.

The lobule of the nose, the major portion of the alae, and the columella may be reconstructed without the addition of any visible scars other than those on the nose itself. This is equally true, also, for partial losses of the upper half and the lateral walls.

Traumatic distortions of the eyelids due to misplacement of tissue and scar contraction are readily and perfectly corrected by properly planned Z flaps. The destruction and distortions due to burns present a different problem requiring careful consideration of the cosmetic as well as the functional results. The generally accepted practice of grafting skin from another eyelid or that taken from the mesial surface of the ear to correct an ectropion usually accomplishes the desired result, but under some circumstances the effect is grotesque. An example is pictured in Fig. 1. The operator limited his planning to one of the triad of procedures, so universally employed. He chose, in this case, to correct ectropion of the upper and lower lids and both lips with split skin taken from the abdomen. The surgery is accomplished perfectly but the appearance of the patient is ridiculous. The greenish gray color of the grafts framed in the surrounding pearly gray-pink skin of the burned face and forehead is startling. The strips about the margins of both lips produce the effect of a made-up clown! There was no art in this procedure except the mechanical one. Rotated, interpolated flaps from the borders of the defects would have corrected all of the functional disabilities with skin that matched and blended with its surroundings.

The reconstruction of a lip is most exacting. Its ultimate function and appearance determine largely the character of the face. Those procedures, too frequently adopted, which cut, shift, and destroy the muscles of expression should never be employed. It may be stated as a general principle that a part or all of a lip, either upper or lower,

can be repaired with the tissues surrounding the defect, provided that there is not extensive destruction of those areas. The partial losses are quite perfectly repaired by the Abbé procedure. The double scar resulting from this implant may later be reduced to a single one by undermining and sliding the skin of the original lip. Larger and total losses can be corrected by utilizing rotated flaps of skin and subcutaneous tissue from the borders of the defect without any damage to the muscles of expression. The lining is provided either by shifting buccal mucosa, by turning a "hinged" skin flap from the margin of the defect and

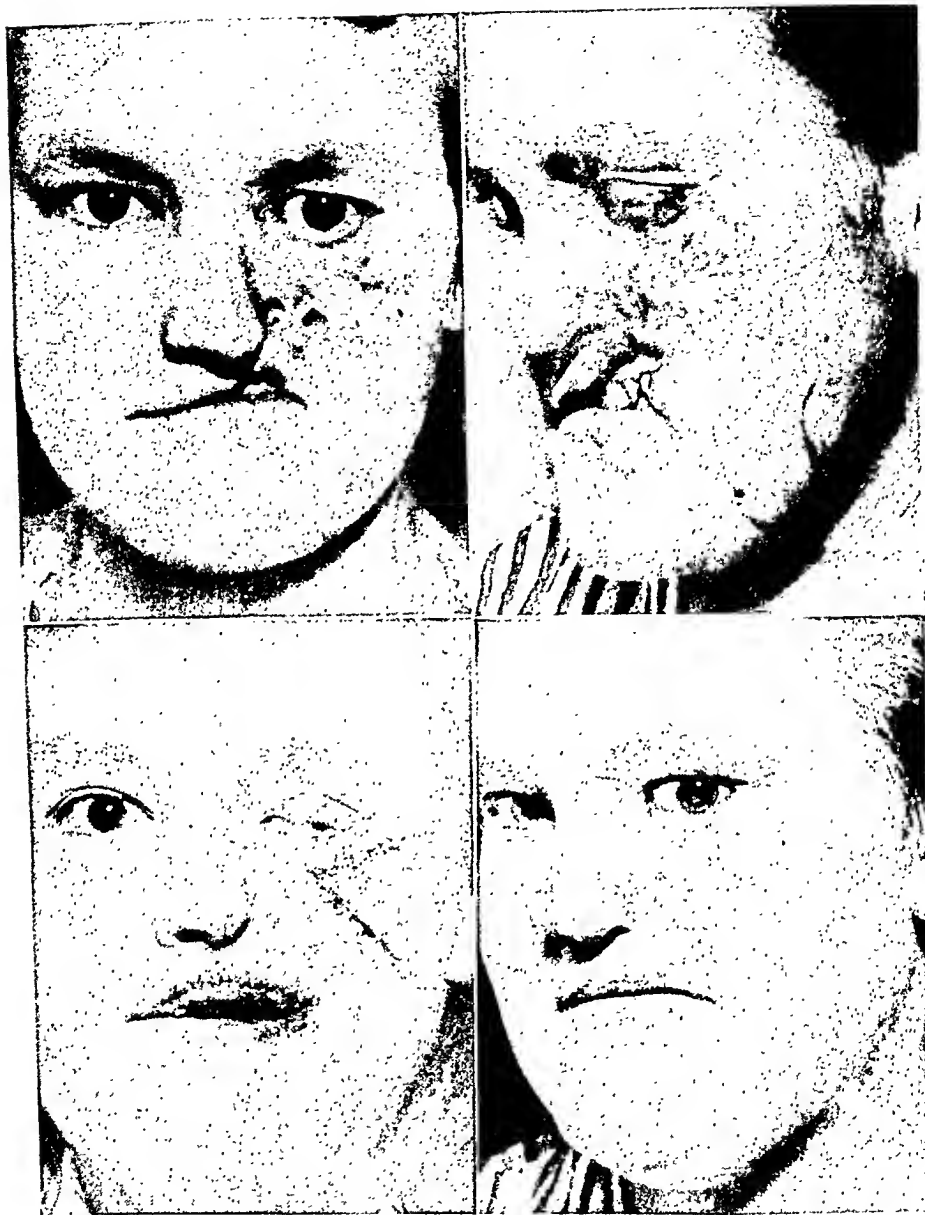


Fig. 1.—Second and third degree burn. Detropion of eyelids and lips was corrected by release and dissection of the scar and grafting with split skin from the abdomen. Color contrasts do not appear adequately. The grafts are greenish gray and the facial scarred skin a pearly gray-pink. The appearance is that of a made-up clown.

later replacing this with buccal mucosa by multiple excision, or by grafting the covering skin flap with hairless full-thickness skin before the reconstruction. The choice of these procedures depends upon the extent of the defect.

The patient seen in Fig. 2 presents a loss of the major portion of the left half of the upper lip, decided atrophy and pigmentation of the soft tissues of the infraorbital area of the face and lateral half of the nose, and ectropion of the left lower lid. This resulted from childhood treatment of a nevus with radium and roentgen rays.

The surgeon had a "choice of procedure" in repairing each of the several defects. The lip has been restored by utilizing rotated flaps of



C.

D.

Fig. 2.—Ectropion, cataract, atrophy of the skin and underlying tissues, arrested bone development, and partial destruction of the lip as the result of roentgen irradiation of a pigmented nevus in early childhood (A). Reconstruction of the ectropic eyelid was done with a full-thickness graft from the upper lid. Surgical adhesions of the lids prevented contraction during the period of organization. Outline of the flaps for reconstruction of the lip and face (B). Construction of the lip was completed, and surgical adhesion of the lid margins and advancement of normal skin into the atrophic area (C). Appearance two months after completion of the repair (D). Compare Figs. 5 and 6. (Courtesy of Smith, Ferris: J. A. M. A. 120: 352-S, 1942.)

Fig. 3.—Carcinoma of the lip and cheek (A), lip and cheek defect after surgical destruction and repair. The skin of the chin has been undercut, elevated, and sutured to the remnant of mucosa in the labial sulcus. Labial and buccal mucous membrane have been sutured to the skin bordering the defect (B). The covering skin flap has been outlined on the cheek and neck and "delayed" (C). A tube of buccal mucosa has been prepared in the cheek for transfer to furnish the vermillion border of the lip (D). Completed lip several months after construction (E). The organized and relaxed flap is ready now for cosmetic correction.

A.



B.

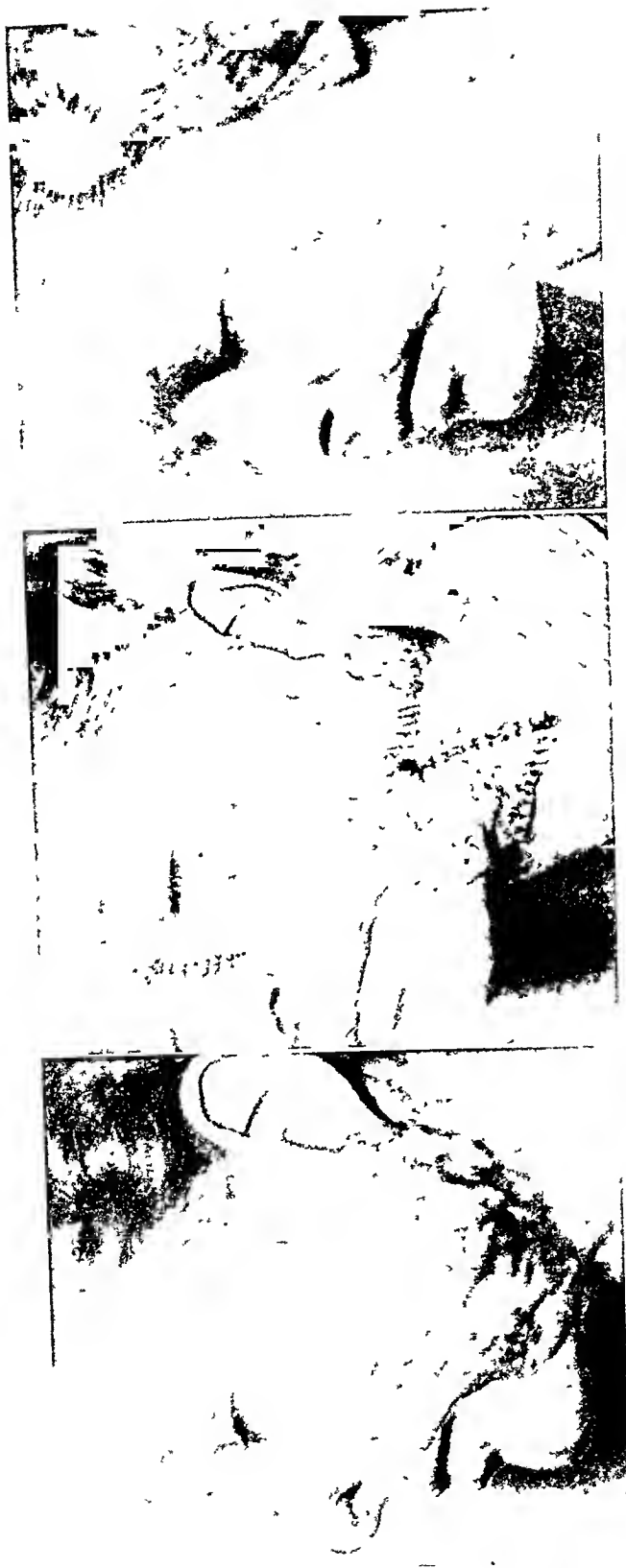


C.



D.





A.

B.

C.

Fig. 1.—Scar from a third degree burn; destruction of the nasal skin covering and the left ala; hypertrophied scar and keloid (A). The nose has been covered with whole thickness skin from the medial surfaces of the ears. A Z-plasty has placed normal skin in position for multiple excisions of the hypertrophied scar on the cheek (B). Appearance as the reconstruction nears completion, the Z-plasty for removal of the scar on the lip is incomplete (C). (Courtesy of Smith, Feil's; J. A. M. A. 120: 352-8, 1912.)

the skin and subcutaneous tissue from the border of the defect without any damage to the muscles of expression. The atrophied, pigmented skin of the face was replaced by normal skin as the result of multiple excisions and Z plasties. The eyelid was repaired by releasing the margin of the lid, creating adhesions between the two lids, and grafting the resulting defect with skin removed from the upper lid.

The patient pictured in Fig. 3 suffered a loss of the major portion of the lower lip and some of the adjacent right cheek from excision of a carcinoma. The remaining skin about the chin was undercut, elevated, and sutured to the remnant of mucosa in the labial sulcus. The buccal mucosa was sutured to the tag of lip on the left side and to the skin about the defect in the right cheek.

The surgeon had choice of procedure and chose to reconstruct with the tissues about the defect.

The lining was furnished by a hinged flap, carrying fat, turned from the border of the loss in the right cheek. The cheek defect thus created was closed by sliding the bordering skin. This lining was replaced later with buccal mucosa from the left cheek by multiple excision. The covering skin was furnished by a rotated flap carrying fat from the left cheek (Fig. 3C) and the vermilion border was supplied by a tubed flap of mucosa from the right cheek (Fig. 3D). The cut ends of the muscles of expression on the right side were ultimately introduced into the reconstructed lip.<sup>14</sup>

The functional and cosmetic results are excellent. The muscles of expression are uninjured and the scarring is minimal.

Functional and cosmetic disabilities of the face such as those resulting from trauma, burns, and pigmentation are corrected most perfectly by multiple excisions, Z plastic, and interpolated flaps rather than by the triad of procedures usually adopted.

In Fig. 4 is presented a patient with hypertrophied scar and keloid following a third degree burn which has been corrected by Z plastic and multiple excisions. Normal bordering skin, which matches perfectly, has replaced the defect. Contrast this with the cosmetic result shown in Fig. 5.

The patient seen in Fig. 5 presented a condition similar to the one pictured in Fig. 4 except that the scar area extended lower on the side of the neck. The surgeon, in one of our large teaching centers, had a choice of procedure. He selected one of the usual triad and tubed a pedicle on the neck and upper thorax. Chest skin which does not blend—it is dead white—was planted in the face and a large additional scar created on the neck and chest. The surgery relieved a functional disability consisting of a distortion of the angle of the mouth and some limitation of motion and left everything to be desired cosmetically. There was no art in this planning and procedure. Contrast the result with that in Fig. 4.



In Fig. 6 is presented a pigmented, hairy nevus on the left side of the face and forehead of a beautiful child. A distinguished colleague followed the usual practice with excellent technical results but with much to be desired in final appearance. The nevus occupying the left temporal region was replaced by a full-thickness graft from the abdomen, which the operator states "retains a lighter shade than the remainder of the normal skin." Several excisions within the nevus on the cheek and replacement of the remainder with a split-skin graft (0.017 inch) from the back completed the repair. Pigmentation and color contrasts are not evident in the photographs.

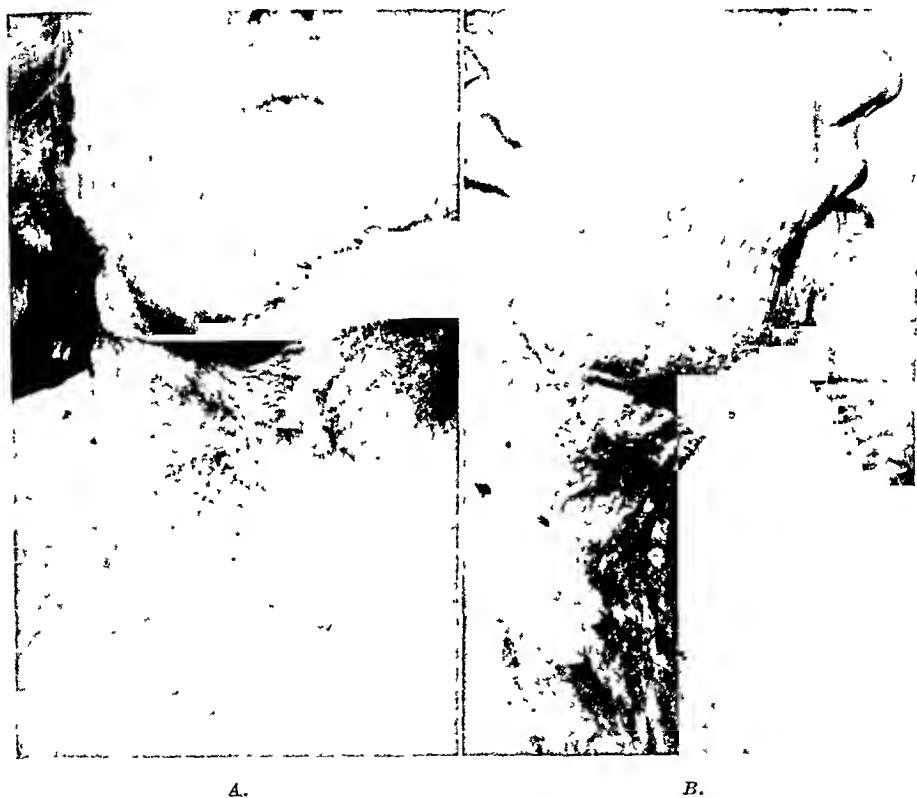


Fig. 5.—Third degree burn of the right cheek, chin, and area of the digastric triangle. Repair was done with a tubed pedicle flap raised from the neck and right chest with the creation of extensive additional scar. The color contrast with the normal facial skin is not shown adequately but the quality of the cosmetic result is obvious. Compare with Fig. 4.

The use of grafted skin on the temporal region was a "procedure of necessity" while the employment of a graft on the cheek was not. A continuation of the multiple excisions combined with a Z plastic to change the line of traction on the lower lid would suffice to replace the nevus with normal bordering skin.<sup>12</sup>

This result affords the opportunity of comparing the cosmetic value of full-thickness and split portions of skin on the same patient. The procedure, despite its skillful execution, replaces a decided cosmetic



Fig. 6.—Hemifacial microsomia (1). The lesion in the temporal region is replaced by a full-thickness skin graft. The lesion on the cheek is partially removed by multiple excision and finally replaced with a split skin graft. Color contrasts do not appear. The graft remains the most irrefragable feature of the face (B and C). Compare Figs. 2 and 7. (Courtesy of Dr. Warren Davis, Smith, Fields, J. A. M. A. 120: 323-8, 1912.)

blemish with another of less degree which remains a definite disability. Compare the cosmetic result with Figs. 2 and 7

The patient pictured in Fig. 7 presents a similar problem in planning. A hemangioma with early malignant change involved the left lip, face, and mesial wall of the orbit. It has been removed by a combination of



Fig. 7—Hemangioendothelioma involving the left upper lip, face, and mesial portion of the orbit (A). Removal and reconstruction by multiple excisions and Z plastic appearance after the initial excision (B). This condition followed a Z plastic and two subsequent excisions. The circular scars result from coagulation of large dilated capillaries which rupture spontaneously (C). The lip and face were covered with normal skin at the end of eighteen months (D). Compare with Fig. 6

multiple excisions and a Z plastic. The large dilated skin capillaries were punctured with a fine hypodermic needle and coagulated. The area is covered with normal skin and presents minimal scarring.

## SUMMARY

1. Most plastic surgeons do not recognize and utilize some procedures which will improve materially the end results of surface repair.
2. The cosmetic result of such repairs merits more consideration.
3. The evolution of and the universal modern practice in facial repair has been profoundly influenced by the popularization of tubed pedicle flaps, free grafts, and rotated flaps from the forehead.
4. Reconstructions utilizing these methods are procedures of necessity rather than procedures of choice.
5. A better understanding of the varied uses of Z plasties, the employment of the principle of multiple excision, and the use of flaps of normal tissue from the vicinity of the deformity will improve greatly the end results.
6. The plastic surgeon in this war has a solemn obligation to the soldier as well as to the casualty victim in civilian life which can be discharged only by careful consideration of the art and finesse of the practice.

## REFERENCES

1. Gentleman's Magazine: Pennants Views of Hindoostan, Oct., 1794.
2. Riverdin, J. L.: Greffe Epidermique, Bull. Soc. de Chirurg. 10: 493, 1869.
3. Riverdin, J. L.: Sur la Greffe Epidermique, Bull. gén. de therap. 82: 71, 1872.
4. Davis, J. S.: The Use of Small Deep Grafts in the Repair of Surface Defects, Am. J. Surg. 47: 280-98, 1940.
5. Ollier, L.: Greffes Cutanées au Autoplastiques, Bull. Acad. de méd. 1: 243, 1872; Skin Grafts, Lyon. méd. 9: 464, 1872.
6. Blair, V. P., and Brown, J. B.: The Use and Uses of Large Split Skin Grafts of Intermediate Thickness, Surg., Gynec. & Obst. 49: 82, 1929.
7. Wolfe, J. R.: A New Method of Performing Plastic Operations, Brit. M. J. 2: 360, 1875.
8. Maas, H.: (a) Ueber Plastik mit Frischen Gestielten Lappen aus Entferneren Koerpertheilen, Arch. f. klin. Chir. 31: 559, 1885.  
(b) Weitere Facle von Plastik mit Frischen Gestielten Lappen aus Entferneren Koerpertheilen, Verhandl. d. deutsch. Gesellsch. f. Chir. 14: 456, 1885.
9. Denonvilliers: Blépharoplastie, Bull. Soc. de chir. de Paris 7: 243, 1856-1857.
10. Morestin, H.: La réduction graduelle des difformités tégumentaires, Bull. et mém. Soc. de chir. de Paris 41: 1233, 1915.
11. Davis, J. S.: The Removal of Wide Scars and Large Disfigurements of the Skin by Gradual Partial Excision With Closure, Ann. Surg. 90: 645, 1929.
12. Davis, J. S., and Kitlowski, E. A.: The Theory and Practical Use of Z Incision for the Relief of Scar Contractures, Ann. Surg. 109: 1001-15, 1939.
13. Smith, Ferris: Some Refinements in Reconstructive Surgery of the Face, J. A. M. A. 120: 352-8, 1942.
14. Smith, Ferris: Surgical Management of Lip Malignancies, Surg., Gynec. & Obst. 56: 782-785, 1933.

## TREATMENT OF BATTLE CASUALTIES AND STREET OR INDUSTRIAL WOUNDS OF THE FACE

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EARLY accurate replacement and fixation of distorted bone and damaged, cut, or torn face tissues will on the average give a quite acceptable, if not really good, restoration within a period to be measured by weeks or a few months. However, whether from battle casualties, or street or industrial accidents, these may be of such severity as to cause one not familiar with their early care or potential outcome to hesitate or putter until the time for easy adjustment has passed. Under combat conditions such delay can be unavoidable, but regardless of circumstance it will too often change a problem of simple readjustment and fixation to one of long-drawn-out hospitalization, repeated operative attempts, and a comparatively poor final result. A relatively minor consideration is that the delayed recovery piles up an unnecessary expense that must be borne by someone—the casualty, the industrialist, or the taxpayer.

The basic principles underlying the care of face wounds are essentially the same as those for wounds in extremities or parietes, but details of procedure and comparative result may vary greatly. An obstructed airway will cause death quicker than will most hemorrhages; an open joint, abdomen, or chest wall demands immediate closure, possibly with simultaneous débridement; but penetration of the mouth in itself means nothing, and on the face débridement is never indicated as a prophylaxis. Restoration of bony relation and the suturing of wounds on the face should be meticulously accurate. The teeth are a unique factor that can be used to gauge fracture adjustment of the bones in which they rest and in most cases are used for fixation, and the dentures which replace them can to a limited extent serve the same purpose.

Early treatment can be summarized under five procedures, enumerated in the order of their importance, the first two being lifesaving and the others influencing treatment time and the quality of result.

1. Establishment of a free airway, control of bleeding, and shock.
2. Make no tight closure of wounds within the floor of the mouth without ample provision for inferior drainage.
3. All displaced fragments or masses of the face bones should be restored to and fixed in proper position as early as is practical; if not immediately, preferably within the first two or three weeks.
4. Do not remove from the face any still-attached bone or possibly viable soft tissue.

5. Other things permitting, all full thickness face and neck burns should be cleaned and grafted within three or four weeks from time of injury.

#### TREATMENT

1. The most demanding indication is establishment of a free airway, but, directly or indirectly, hemorrhage is likely the common cause of death in face wounds. At the field hospital or even a dressing station, the bleeding vessel can be caught or effective packing might be done, even of the pharynx after a stab tracheotomy. Where need be, the common carotid might be ligated; if the patient is under 30 years of age the latter is not apt to cause permanent brain damage. In these cases, death might result from exsanguination, aspiration, or shock; therefore, one so wounded should be placed semiprone to give a free airway during transportation and while making attempts to control bleeding. An old, somewhat heroic procedure for uncontrollable bleeding is to hold the man erect until he faints and then quiet him with a small dose of morphine. An early transfusion can again start bleeding from an unligated but clot-controlled vessel wound.

2. The prohibition against closing wounds in the floor of the mouth stands as stated, for it can initiate a spreading induration, possibly fatal under conditions of transport.

3. Next to life preservation, the most demanding indication in the care of the recently injured regards continuity of the bony framework.

Fractures in the mandible do not impact and displacement here, due to masseter pull, will vary with the position, direction, and number of fracture planes. Those within the maxillomalar mass or "upper jaw" are frequently impacted, and when displacement is present is due to the original violence or to gravity. Jaw fractures in most instances, if seen early, can be diagnosed by digital examination and intraoral inspection; where convenient, this may be checked by x-ray, but there is seldom reason to allow want of a radiograph to delay replacement and fixation beyond the time of election.

Most fractures of the body or ramus of the mandible, either single or multiple, should have immediate restoration of occlusion by the Gilmer plan of wiring the lower to the upper teeth. Those of a tooth-bearing area are usually contaminated by mouth secretion, and an early stab drainage opening made from under the border into each fracture plane will largely prevent the induration and death of partially detached bone fragments, due to pocketed mouth secretion. Displacement of an anterior segment that lacks teeth suitable for anchorage can be controlled by a wire loop passed around the segment, closely hugging the bone, and fixed either to a tooth or wire arch above, or by releasing muscle-pull with an open-bite (Gunning) splint. For body fractures of edentulous patients, the dentures make an excellent splint when

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of the nasal airway is likely all that is required, but late correction has in our hands proved quite a formidable procedure. A mass sagging of the face after fracture through the orbits is also treated by the same dental fixation even though both jaws be broken, but for an interval the maxilla might advantageously be supported by the Gilmer plan of reversing the Kingsley splint, with the bandage encircling the vertex. This latter is especially applicable for patients with nasal obstruction or those seen late but with no fixation. However, this inaccurate up-pull should be discarded and the two arches wired in occlusion before bony fixation takes place; otherwise a permanently uptilted dental arch is likely to result. The cooperating dental surgeon will be familiar with the types of splints mentioned and with dental wiring.

In appropriate cases, wiring the upper to the lower jaw is being discarded in favor of direct fixation of the fractured bones by external splints attached to the fragments by screws piercing the soft tissues or by metal spikes or wires driven lengthwise through the bone. The latter appears to be simpler and worn with much more comfort.<sup>3</sup>

Displacements of the zygomatic bone, commonly called fracture of the antrum, are usually downward, backward, and outward, with outward bowing of the zygomatic process, and firmly impacted. There are various plans of breaking this impaction; the one commonly advised is insertion of pries or hooks through external incisions, using the frontal bone as a fulcrum. However, the displacement frequently includes an unrecognized bursting fracture of the orbit with downward displacement of the floor; if this latter is not included in the replacement it will later still be revealed by the sunken and depressed globe that will become evident as the orbital swelling and hemorrhage subside. Both for this reason and also the ease with which the cheek bone can be replaced, we open the antrum through the canine fossa, the impaction is broken up with a pry, the floor of the orbit is examined and, if need be, pushed up into place by the examining finger within the antrum; the body of the bone and the floor are fixed in place by a folded strip of mildly antiseptic gauze packed into the cavity in an orderly manner, the end protruding through a small opening in the unsutured anterior part of the mucous incision. When this gauze strip is removed three weeks later, the flared-out trap door of antral wall is pushed into place.

For displacements of the orbital borders, the nose, or the bony part of the external auditory canal, impactions should be broken up and proper relations established; within the nose, mucous tears should be closed with a few tacking sutures, and displaced cartilage held in place by a splint or gauze packing.

Impacted nasal fractures can usually be freed within the first three weeks by the prying elevator which will permit the broken or bent septum to resume natural position, but the replaced bones might need



fixation. One or possibly two of the three following plans will accomplish the latter. (1) For a depressed dorsum with lateral spreading of the nasal bones, the bridge is pried free and a heavy curved "surgical" needle carrying a wire or strong silk suture transfixes the base of the nose through the fracture lines, above and below, the needle entering and emerging from the skin slightly lateral of the fracture lines in such a way as to draw in some of the laterally displaced proper nasal covering. The bones are held in normal relation by tightening the mattress suture over a narrow lead plate at each side of the nose. (2) For lateral mass displacement, use the wire-carrying needle inserted so as to engage either the anterior nasal spine, the lower corner of the opposite nasal bone, or the dorsal border of the cartilage, to form a subcutaneous loop, both ends of which traverse the vestibule and the cheek tissue, to emerge above and anterior to an anchoring upper molar tooth to which the guy wire is attached after drawing the nose into a somewhat overcorrected position. (3) After certain complicated or comminuted fracture reductions, the bridge of the nose can best be held in position by an intranasal armature that below is attached by a universal joint to a vulcanite base plate cemented to the incisor teeth; any persistent uptilting of the tip can, if necessary, be drawn by a second guy wire that transfixes the septum near the dorsum. This splint is particularly useful where the freed nasal bones have been driven in deeply between the maxillary processes or where there is much comminution of bones and septum. Deep backward displacement of the bridge might easily be complicated by an unrecognized fracture of the cribriform plate of the ethmoid, and a week or ten days might be profitably expended on prophylactic measures directed toward protecting the cranial contents. This same delay applies also to the replacement of a pushed-in fragment of the outer wall of a frontal sinus and to displacements of the upper orbital border, but those of the outer border of the orbit can be replaced immediately.

Regarding the release of impacted fractures of the face, especially those of the zygomatic bone, and deep backward displaced nasal bones, or those involving dentigerous bone, complicated by fever, it is a perfectly safe practice to delay breaking up the impactions for a week or ten days until some local immunity to infection is established naturally or by medication. In two cases of early forceful replacement of the zygomatic bones, I have seen a limited bone necrosis follow the manipulation, and in several cases of fracture of the maxilla there has been considerable elevation of temperature that might have been related to some previously quiescent apical abscess. A posteriorly displaced nasal bone impinging on the cribriform plate of the ethmoid might have caused a dural tear, which might be really unfortunate with an ethmoid or chronic nasal suppuration.

4. Wherever tissue condition permits, the lips, nostrils, nasal alae, columella, ears, eyelids, trap door flaps of skin, and displacements of the nasal cartilages or mucosa should be immediately tacked in place as should also mass displacements of face tissues. A soldier with wide cheek tears or loss might be rendered transportable earlier and with greater comfort by following the British practice of tacking the mucosa to the skin across the raw surface.

The classic "débridement" has no place in face injuries, but after the removal of shreds fresh clean wounds may, possibly as a first-aid procedure, be drawn together, preferably with catgut that engages the subcutaneous tissues and will not risk added suture scars that might permanently mar an otherwise very good secondary correction. Scraped areas of skin, such as occur in street injuries, should be immediately scrubbed with the brush until all dirt and foreign matter are removed. The implantation of burnt grains of black powder should be individually removed with a pointed bistoury and each little wound sutured before the powder grain has time to disseminate.

5. Burns that cause full thickness skin loss can by proper care, local and general, usually be made ready for split skin grafting within three to eight weeks after the injury. When the graft is applied to such movable areas as lip, cheek, or eyelid, the graft with its dressing is best fixed by suturing the latter in place. This type of graft, where unopposed, will shrink possibly 60 per cent, but early coverage will save an immense amount of suffering and expense, and will allow later replacements or additions to be done at times of election.

With the greater naval activity now occurring, the increasing predominance of air fighting, and the eventual rapid movement of ground troops, it seems likely that the proportion of war injuries of the face will greatly decrease. However, to the individual casualty, the proper care of his damaged face will remain just as important as it was when this type of surgery was well in the spotlight.

#### REFERENCES

1. Blair, V. P., and Byars, Louis T.: Treatment of Wounds Resulting From Deep Burns, *J. A. M. A.* 110: 1802-1804, 1938.
2. Blair, V. P.: Relation of the Early Care to the Final Outcome of Major Face Wounds in War Surgery, *Mil. Surgeon* 92: 12-17, 1942.
3. Brown, James B., and McDowell, Frank: Internal Wire Fixation of Jaw Fractures, *Surg., Gynec. & Obst.* 74: 227-230, 1942; 75: 361-368, 1942.

# EARLY TREATMENT OF GUNSHOT WOUNDS OF THE FACE AND JAWS

## CASE HISTORIES OF PATIENTS TREATED DURING WORLD WAR I

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SINCE the outbreak of World War II, the treatment of gunshot wounds of the face and jaws has been extensively discussed. It is, therefore, quite natural for me to refer to my own clinical records and papers written during the last war, and to judge them after twenty-five years of added experience in maxillofacial and plastic surgery. It is gratifying to note that the basic methods of treatment recommended then have not changed. It is important to record that much progress has been made in the use of the sulfanilamide drugs, in the treatment of shock, in the administration of intravenous fluids, and in the bacteriology of wounds. Many new appliances have been suggested and designed for the immobilization of fractures of the facial bones. Medical, surgical, and mechanical progress have not modified the principles of treating jaw cases. For these reasons I am taking the liberty of using parts of my former articles to express my present views.

The treatment of facial injuries may be divided into two distinct periods. The first, or early period, which covers the three to four weeks following the receipt of the wound, is the most critical for the patient. This is the period of initial exhaustion, of loss of blood, of pronounced sepsis, and of great pain and mental depression. This is also the time at which alarming complications, such as bronchopneumonia, secondary hemorrhage, and general infections are most likely to occur.

After this critical first period, the patient enters the second period. At this time, depending upon the severity of the case, the treatment of the patient is confined chiefly to further repair of the bony tissue by means of splints, to the construction of prosthetic appliances, to minor operations, and to plastic operations for the reduction of the facial deformity. Following this is the convalescent period.

In this discussion emphasis will be placed on treatment and complications of gunshot wounds during these early stages. First it is well to note the differences between war and civilian injuries, or to use two convenient terms, gunshot and accidental wounds.

Accidental cases are nearly always caused by a fall, a blow, a kick, or an automobile collision; something hitting the victim, or the victim hitting something violently. The patient's life may or may not be in danger. He usually reaches a hospital within four to six hours after injury; facial injuries are susceptible to primary suturing, the lines

of fractures are well defined, there is no loss of bone except teeth and alveolar process, infection is not serious, and complications are not frequent.

By contrast, in gunshot wounds the missile may carry away anything from a few spicules of bone to a considerable part of the face. The foreign body has caused the shattered bone to tear the soft tissues with almost explosive violence. Multiple fractures radiate in many directions. The lacerations of the muscles and the destruction of bone obviously indicate free movement of the remaining parts. In this case the face is horribly mutilated but the gaping aspect of the wounds facilitates an appraisal of the damage with considerable accuracy.

A large number of facial wounds with a small entrance and a small exit are seen. The severity of such wounds depends almost entirely upon the anatomic location and the path of the piece of metal. Through-and-through wounds of the anterior part of the face may cause extensive destruction of the teeth and comminution of the bone, but in the main do not lead to alarming complications, providing adequate treatment at an early period is effected. Contrary to this, however, wounds involving the posterior part of the face, especially those of the pharyngeal, carotid, and lower molar regions, are particularly dangerous. Such injuries may cause bilateral fracture of the mandible, and in many cases be situated near enough to important blood vessels to give a probable chance of severe hemorrhage.

The tongue and the floor of the mouth are liable to serious injury along with either the upper or lower jaw. If the injury is limited to the apex or dorsum of the tongue its profuse blood supply promotes healing in spite of severe laceration or even sloughing. The tongue may be greatly swollen and often dark purple in color, and, in spite of the open position of the mouth, it may protrude beyond the lips and at times seriously effect the breathing.

*Wounds of the Lower Part of the Face.*—Wounds of the lower lip are common in injuries where there is an obscure entrance posterior and inferior to the mandible on the neck or face. The missile has traveled forward, causing extensive laceration and fracture. This type is sometimes very extensive, involving loss of the chin, the sublingual region, and a large part of the mandible. These cases are relatively easier to treat than those of the posterior face and throat because the wounds are accessible, are less prone to complications, and the lacerated tissues may be repaired at an early date.

*Wounds of the Upper Part of the Face.*—Injury to the upper part of the face is less common, but it may be more dangerous and ultimately lead to greater deformity, particularly if the injury extends to the nose, the eyes, the ears, or the zygomatic region. The maxilla is prone to great comminution and considerable loss of bone, and in some rare instances practically the entire maxilla and the septum of the nose have

been carried away.' The involvement of one or both antra is common, and might almost be said to be a certainty. Fractures of the cribriform plate in injuries of this type are the cause of most fatalities.

Most soldiers, when questioned on their arrival at the hospital, state that while they bled quite profusely, they were able to reach the dressing station either unaided, or with the help of a stretcher bearer. However, loss of blood combined with fatigue and exhaustion naturally tends to lower the resistance and make the patient more susceptible to further complications. Having all this in mind, it is necessary that the preliminary treatment should consist of making the patient comfortable, taking measures to control infection, and increasing the resistance of the patient in preparation for further treatment.

The foregoing statements represent a fairly accurate description of face and jaw injuries as seen and described twenty-five years ago, and there is no reason to think that they will be different at the present time.

I shall not discuss various local measures such as feeding, nursing care, dressing of wounds, or the general measures such as administration of fluids, antitetanus serum, and chemotherapy, but will limit this discussion to a few of the important aspects of treatment.

A careful study of a large number of treated cases has revealed some interesting facts that are well worth recording.

1. The general care of maxillofacial cases is more effectively carried out when such patients are segregated in a certain designated center, or when that is not possible, a section of the general hospital reserved for the care of patients with maxillofacial injuries. The difficult problems of feeding, nursing, and frequent dressings can only be effectively carried out by specially trained medical officers, nurses, and attendants. It has been found that patients with jaw injuries are happier when they have their own quarters and recreation facilities apart from the other patients in a general hospital.

2. All gunshot wounds are infected from the beginning, no matter how soon the patients are admitted to the hospital; consequently, they must be treated as such. After making the patient comfortable with supportive treatment, our procedure has been to apply frequent warm fomentations over the wound, irrigations to the mouth, and at the proper time (perhaps within the first week) clean the wound surgically, preferably under local anesthesia. This consists of the removal of nonvital tags of lacerated tissue, broken-down teeth, and loose fragments scattered throughout the wound.

3. There has been a natural temptation to suture external facial wounds as soon as the patient arrives at the hospital, with the wrong assumption that this will prevent subsequent deformity. This hasty measure has caused a good deal of harm. Suturing wounds when the wound is already infected and greatly swollen does not minimize the deformity, but it tends to block drainage and complicates the procedure for the immobilization of the bone fragments.

It is possible, however, once the infection is under control, to resort to partial suturing of the radiating borders of the wound, and suturing of vital but misplaced sections of tissue into their proper positions. This suturing should not, under any circumstances, interfere with sufficient drainage of the wound or with the dental surgeon's free access to the mouth for the performance of various manipulative procedures for the immobilization of fractures. For example, if there is a large gaping wound of the lower lip, extending toward the neck, suturing of the lip should be postponed until proper dental splints have been inserted for the immobilization of the mandibular fragments.

4. Great stress has been placed on early immobilization of mandibular fractures as soon as the condition of the patient permitted it, because it was found that such a procedure made the patient more comfortable, the feeding problem less difficult, and the healing process of the wound was hastened. The general picture of the laceration was simplified and earlier repair of the lips was made possible. Immobilization should be carried out within the first week or two after the injury, unless some local or general complication makes it impossible to do so, because at this stage the bone fragments are easily manipulated and brought into alignment. The problem of adjustment of dental splints is also less difficult at this stage.

5. The complications at this stage of the treatment are local abscesses, general sepsis, bronchopneumonia, erysipelas, and secondary hemorrhage. Many of these complications are likely to appear in any wound, and are not altogether typical of gunshot wounds of the face and jaws. Secondary hemorrhage in gunshot wounds is the cause of most of the fatalities, and therefore it is worth while to discuss this subject in more detail.

In World War I, at the British Base Hospital No. 20 in France, there were 34 cases of mild and serious hemorrhage occurring from among 400 patients.<sup>1</sup> Sixteen cases (8.5 per cent) required operative measures for the control of hemorrhage, under general anesthesia, while the remaining seventeen cases were successfully treated by packing, clamping, or ligation of the bleeding point under local anesthesia. The majority of these hemorrhages occurred between the fourth and twelfth day following the injury; three cases took place between the thirteenth and nineteenth days; and one hemorrhage occurred on the forty-fifth day following injury. In this last case the maxilla, mandible, and skull were all fractured.

Secondary hemorrhage occurs more frequently at night, according to our records. It is not always easy to determine the source of hemorrhage, but one is principally guided by the location of the entry and exit wound in relation to the anatomic location of the blood vessels. Injuries of the upper half of the face are often accompanied by nasal

bleeding, which probably originates from the branches of the internal maxillary artery. Among ninety-one cases of fractures of the maxilla there were only four cases of hemorrhage recorded. Open wounds with extensive lacerations of the soft tissues do not usually present a serious problem, because the free drainage favors early healing of the wound, and being exposed, the bleeding point can be easily detected and brought under control by ligation or packing. In injuries involving the lower half of the face we must consider probable bleeding points from the (1) facial arteries, (2) the mandibular arteries, and (3) the lingual arteries or their branches. The location of the wound and the path of the foreign body will usually give the surgeon a fairly good idea of the source of bleeding. The facial artery, being more or less superficial, is easily brought under control by direct ligation of the bleeding point. Hemorrhage from the mandibular artery has not been frequent and is seldom serious. It usually occurs when the comminution of the mandible is at the region of the angle of the jaw. Bleeding which occurs as a result of an extensive wound at the molar region of the lower jaw, with accompanying injury to the floor of the mouth and tongue, is often from the lingual arteries or their branches. Such cases have been the most common and are the most serious. From a total of thirty-four cases, seventeen were from this source and twelve required operative measures to control the hemorrhage. Such cases have certain recognizable characteristics, the entry and exit wound usually being small, the mandible fractured bilaterally, the floor of the mouth lacerated, and the tongue usually perforated and greatly swollen.

*Treatment of Secondary Hemorrhage.*—The most important preventive measures are those taken toward the control of infection which have been described in the foregoing pages. It must be remembered that in spite of the patient's general condition, the jaw requires some means of support in the form of a temporary splint, as it has been observed that the cases which are most prone to bleeding are those that are accompanied by fractures with extensive displacement and mobility.

The attending nurses are instructed to report even the slightest seepage of blood from the face and jaw wounds. Although it may appear quite harmless at first, it is noted that most hemorrhages start with slight oozing of blood, perhaps continuing for hours, until it eventually becomes a profuse hemorrhage. Much valuable time will be lost if this precautionary measure is not followed.

A ward for "jaw cases" must be equipped with a special emergency tray consisting of ribbon gauze, swabs, artery clamps, forceps, dental mouth mirror, head mirror, adrenalin chloride, hydrogen peroxide, and a novocain outfit. Surgical needles and sutures must also be handy for instant use. As soon as the hemorrhage occurs the attending surgeon should send for the medical officer in charge who appears at the ward as soon as possible.

The immediate stoppage of the hemorrhage is accomplished by syringing the mouth with hydrogen peroxide, cleaning the blood clots, and packing the wound with gauze saturated with hydrogen peroxide. In order to hold the packing in the floor of the mouth a specially devised surgical artery clamp has been of considerable help. It has been our experience that hemorrhage from the lingual arteries, as well as repeated hemorrhage from undetermined origin, cannot be properly arrested by packing, therefore, as soon as the patient recovers from the shock, operative treatment should be resorted to.

Since World War I much knowledge has been acquired in the treatment of shock and control of hemorrhage and physiotherapy, as well as methods of administration of anesthetics. Military surgeons at present have greater facilities to combat complications mentioned in this communication.

In the foregoing pages an attempt was made to call attention to some important points in successful early treatment soon after injury. It is often necessary, once the convalescent stage is reached, to repair further the work on the soft tissue of the face, nose, eyelids, and lip, for improvement of the facial outline. Such a procedure may often require careful planning. Therefore, there is no necessity for hasty action. The wounded could be transferred to hospitals where ample facilities are available for such treatment.

Plastic procedures are successfully carried out when the tissues have become more healthy. As a primary measure, physiotherapy in the form of heat, massage, diathermy, etc., becomes indispensable while the patient is convalescing. When the patient, in addition to loss of soft tissue, has also suffered partial destruction of teeth and alveolar processes and palate, it is absolutely necessary to replace these missing parts with prosthetic restorations before any measure of repair of the lips and cheeks is undertaken. Such supporting appliances are indispensable as they form a framework for the repaired soft tissues and allow them to heal without contracture.

It is often also necessary to resort to transplantation of bone as a certain number of mandibular fractures will suffer nonunion, either due to hemorrhage or loss of bone, or following infection. Transplantation of bone should not be attempted until all the evidences of infection have disappeared, soft tissues of the area are free from dense scars, and finally, all necessary preparations for splinting of the jaw have been provided.

#### CONCLUSIONS

Treatment of gunshot wounds of the face and jaws is divided into two distinct periods: first, the early period which is the most critical stage of the patient's life, and covering somewhat between three and four weeks following injury. The second period is confined chiefly to further



repair of the deformity This article is concerned with treatment of the first period only, second, the treatment of maxillofacial patients is more extensively carried out when such patients are segregated in an especially designated center where facilities are adequate; third, all gunshot wounds are considered infected wounds and treated as such; fourth, primary suturing of face wounds immediately after injury is found to be contraindicated in gunshot wounds of the face but late primary suturing within two weeks or so has been found practicable; fifth, immobilization of fragments should receive especial attention before late primary suturing is done, sixth, complications in early period of treatment are discussed and special emphasis given to secondary hemorrhage as a cause of most fatalities



Fig. 1.



Fig. 2.

Fig. 1 (Case 1)—Photograph showing a large wound on the right side of the face and laceration of the corner of the mouth. Portion of the right upper lip was destroyed. There was comminuted fracture of the right side of the maxilla, antrum exposed.

Fig. 2—The photograph of the patient (Case 1) before he was operated on for final repair of the upper lip.

The case histories are selected to give an idea of the procedure that was followed in the treatment of such cases of twenty-five years ago. No attempt was made to resort to lengthy discussion of the various operations, first because the main purpose of presenting these case histories



Fig. 3.—Appearance of the patient (Case 1) following the repair of the upper lip

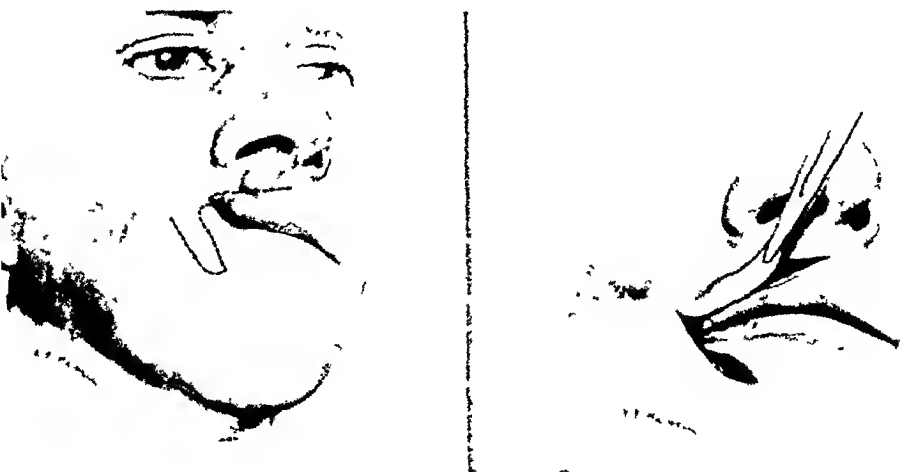


Fig. 4.—Diagram showing method of repair of the upper lip in Case 1.

is to call attention to the various steps that had been taken as well as the interval between each step in the course of treatment. We will find that some case histories are not complete. This is due to the fact that patients are often evacuated earlier because of military necessity.



Fig. 5.

Fig. 5 (Case 2).—A large wound extending from the right first molar to the lower lip. The right first molar is practically missing. There was a comminuted fracture of the lower jaw extending from the right first molar to the second bicuspid tooth on each posterior fragment.

Fig. 7.—Final picture of patient in Case 2.

Fig. 7.

Fig. 7.—The lower lip to the neck. The comminuted fracture of the lower jaw, only the second bicuspid tooth, only the

Case 1 (H).—This patient (H) was admitted to No. 20 General Hospital April 30, 1917, showed a large wound on the right side of the mouth extending along the cheek for 4 inches. The right upper lip was destroyed. The entry wound was 4 inches long. The lower jaw, including the first and third molars, was missing. The right side

24, 1917, and admitted to the hospital. Examination of the wound (Fig. 1). A piece of the mouth, the upper lip, was missing. The right side

On May 8, 1917, operation for the upper jaw. The missing part of the upper jaw was replaced with part of the lower lip, a

down. On July 17, 1917, seventy-eight days after admission, he was operated upon and the scars of the face were excised (Fig. 2).

Aug. 2, 1917, another operation was performed to correct the shortness of the right upper lip and the displacement of the corner of the mouth. The red borders of the upper right side of lower and upper lips were separated about an inch. A flap was taken from the side of the right lower lip and used to fill the triangular raw space (Figs. 3 and 4).

On Aug. 17, 1917, further correction of the right corner of the mouth was carried out. Aug. 27, 1917, the patient was evacuated to England.

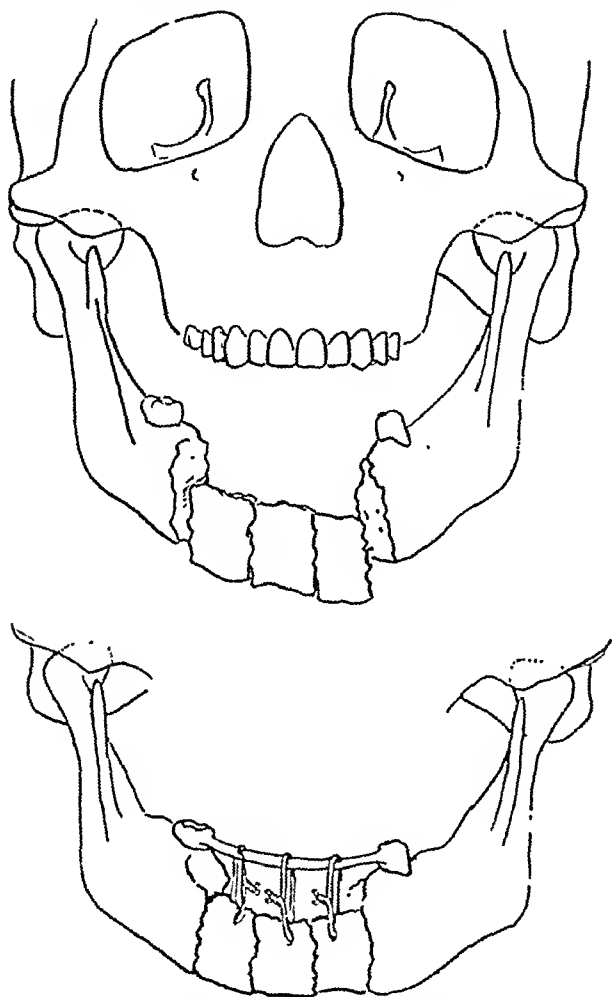


Fig. 6.—A splint constructed of bands for the existing teeth, connected by heavy arch wire, is cemented in place to immobilize the posterior segments. This arch follows the mandibular curve at about the normal lingual gingival margin of the lower teeth. Wire sutures are then passed through the exposed ends of the displaced anterior fragments and they are lifted toward the arch into a more normal alignment.

CASE 2 (C).—This patient, aged 31 years, was wounded June 27, 1917, and admitted to No. 20 General Hospital on June 30, 1917, three days after injury. There was a large wound of the face extending from the lower lip to the neck, separating the sublingual region, and the chin was practically destroyed. There was a compound fracture of the mandible from the left second bicuspid to the right molar



Fig. 8.



Fig. 10.

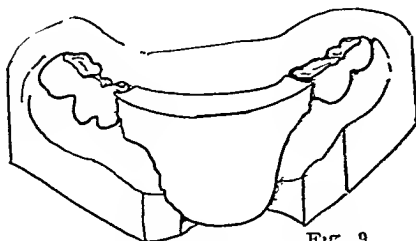
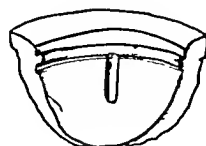
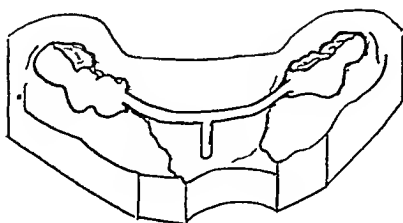


Fig 9.

Figs. 8-10. (For legends see opposite page.)

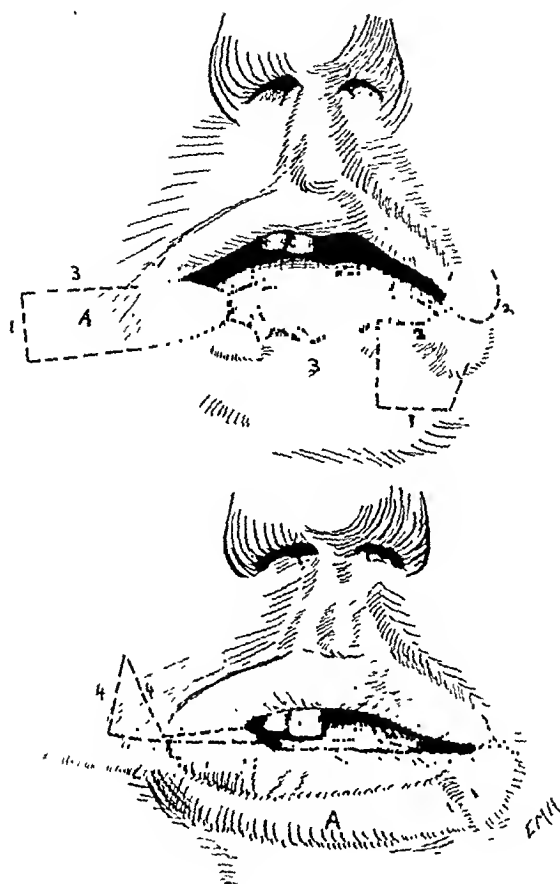


Fig. 11.—a shows a method of outlining flaps which together work well in creating a good functional and cosmetic lower lip. Flap A is rotated 180 degrees and the opposite flap is rotated 90 degrees. Each carries muscle tissue and is sustained by a good-sized blood vessel. Both together supply enough white skin and mucous membrane for the new lip. The tongue-shaped incision 2 in the first figure lies practically entirely in the mucous membrane and provides an edge for attachment for the flap, and itself contributes mucous membrane.

b shows the rotated flaps joined together, the lip completed and an advancement of the buccal mucous membrane of the lower lip to create part of the new cutaneous line. In this diagram the scheme 4, 4 shows a bulge which must be eliminated to get the final result. This is done about four weeks after the first operation.

Fig. 8.—Photograph showing loss of greater part of the lower lip. This patient also had a comminuted fracture of the anterior part of the mandible. The fracture was immobilized seven days after admission to hospital, by a band-and-wire splint with vulcanite support similar to one shown in Fig. 9.

Fig. 9.—Diagram showing a band-and-wire splint with a perpendicular T wire. A vulcanite piece with grooves is made to fit to the curve of the arch wire. This movable part has sufficient bulk to act as a framework to support the lip when teeth and alveolar processes are lost.

Fig. 10.—Photograph showing condition of patient before the repair of the lower lip (Case 3).



Fig. 12—Condition of patient five months after injury (Case 3).



Fig 13—Patient suffering extensive lacerated wound with comminution of mandible

region, and the symphysis was destroyed. There was bony separation of about one inch, and there were only two serviceable teeth, the right lower molar and the left bicuspid (Fig. 5).

On July 8, 1917, under local anesthesia, all the broken down teeth and loose particles of alveolar bone were removed and the main posterior fragments were immobilized by a band and wire splint. The displaced anterior fragments of bone were raised by means of suspended wires (see Fig. 6).

July 15, 1917, the patient was operated upon and the radiating borders of the wounds under the lower lip were sutured. On July 24, 1917, a chin piece was applied for further support of the soft tissues.



Fig. 14.

FIG. 14.—The same patient four months after injury (Case 4).



Fig. 15.

FIG. 15.—Photograph taken seven months after injury (Case 1).

July 30, 1917, the necrotic bone was removed, and a molar root on the right and two lower teeth on the left extracted. The root of the second molar was exposed to be used later as an abutment for a splint.

On Oct. 9, 1917, the patient was operated upon and the scars of the chin and neck were repaired. An impression was taken for a new dental plate, and this was placed in the mouth Oct. 14, 1917.

*Remarks.*—The wound of the face healed with slight retrusion of the chin, due to loss of the symphysis (Fig. 7).

CASE 3 (P).—This patient was wounded May 5, 1917, and was admitted to No. 20 General Hospital May 7, 1917, two days after injury. There was a shrapnel wound



of the lower lip and left cheek, with destruction of the greater part of the lower lip and laceration of the left corner of the mouth about one inch along the cheek. There was an extensive comminuted fracture of the mandible from the first molar on one side to the first molar on the opposite side, with the anterior segment displaced downward (Fig. 8).

On May 12, 1917, the wound was debrided by the removal of loose alveolar bone and the loose right first bicuspid and cuspid teeth.



Fig. 16 (Case 5).—An extensive wound of the chin and neck, laceration of the lower lip and chin extending along the neck to the right angle of the jaw. The patient had a severe compound fracture of the lower jaw, with considerable loss of tissue from the first molar to the first molar on the other side.

On May 12, 1917, the wound was debrided by the removal of loose alveolar bone and the loose right first bicuspid and cuspid teeth. May 14, 1917, the right bicuspid, left bicuspid, and first molar roots were also extracted. There were now no teeth left between the second molars. A band and wire splint, with vulcanite support, was cemented over the existing teeth (Fig. 9). On May 18, 1917, eleven days after admission, the patient was operated upon and the radiating borders of the wounds were sutured. A flap of mucous membrane from the left cheek was sutured to the raw surface of the lip to form a red border for future plastic operations (Fig. 10).

June 9, 1917, the patient was operated upon and the first stage of reconstruction of the lower lip was carried out (Fig. 11a). On June 29, 1917, the patient was operated upon and the upper corner of the lip was raised by cutting off a triangular section, and the mucous membrane was trimmed to a better contour. Part of the mucous membrane and underlying fatty tissue was removed to eliminate the thickness of the lip (Fig. 11b).

Sept. 18, 1917, another operation was performed in order to correct a peculiar fullness under the lower lip. The left corner of the mouth was raised slightly to improve the outline. On Oct. 3, 1917, the patient was classified for evacuation to England (Fig. 12).

CASE 4 (M).—This patient was wounded on April 13, 1917, and admitted to No. 20 General Hospital on April 19, 1917, six days after injury. He suffered an extensive gunshot wound of the left side of the face with lacerations of the corner of the mouth extending toward the angle of the jaw and to the neck below the border of the mandible. There was considerable loss of bony tissue from the median line to the angle of the jaw (Fig. 13).

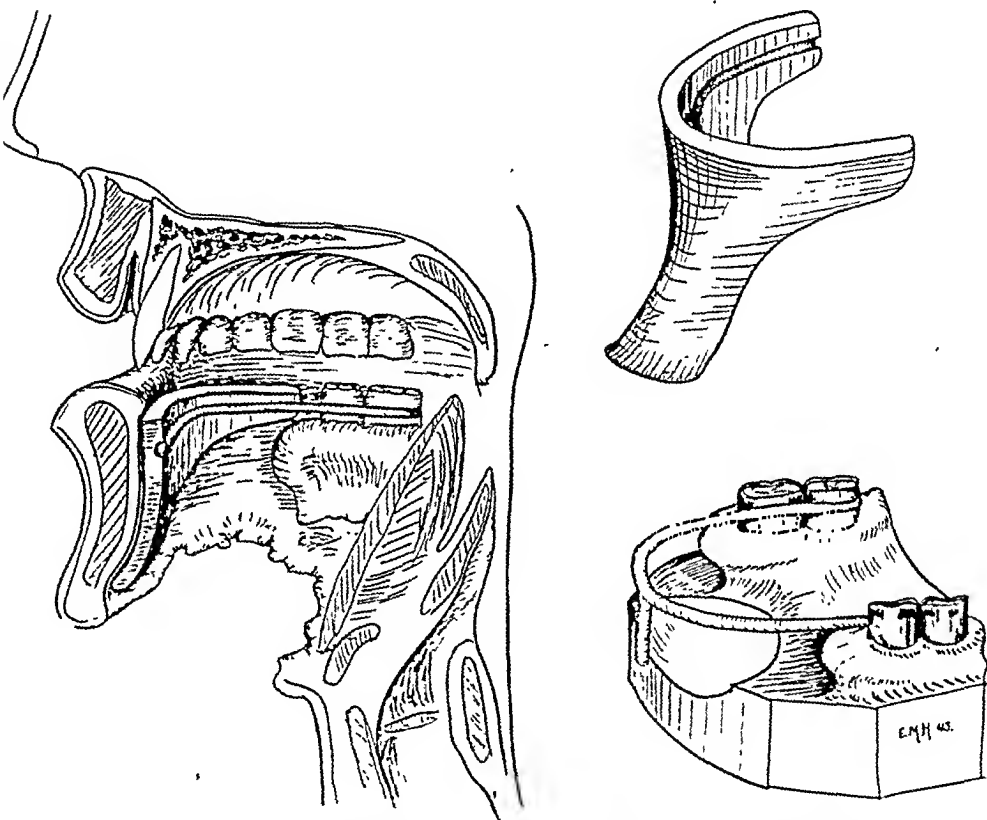


Fig. 17.—This type of band-and-wire splint was used in this case to maintain the existing posterior fragments of the mandible in their normal position, while the vulcanite support, being concave at its lower end, acts as a seat to support the lower lip and chin and prevents undue contracture. In the absence of bony framework, such supports are absolutely essential for the prevention of gross deformities (Case 5).

On April 29, 1917, a swaged cap splint with a T-shaped wire extension was cemented over the existing teeth. A large displaced fragment of bone was connected with the exposed end of the ramus with brass wires.

June 17, 1917, an operation was performed consisting of partial suturing of the soft tissues of the face. On July 1, 1917, an external appliance (chin piece) was constructed for the support of the cheek at the left angle of the mouth. Aug. 14, 1917, the patient was operated on, and the corner of the mouth which was drooping downward was raised (Fig. 14).

A new x-ray was taken, Sept. 18, 1917, which seemed to show new bone formation. In view of this, an upper splint was made and cemented over the teeth, and the lower jaw immobilized to the upper. Nov. 7, 1917, the ramus on the left side was pulled upward to avoid the danger of a false union. To do this (1) the lower end of the ramus was exposed by reflecting the mucous membrane back and holding it in position by mattress sutures; (2) a hole was drilled through the end of the ramus, and a stout wire passed through the drilled hole, connected with the bar of the lower splint, and tied with silk. Nov. 26, 1917, the wires were removed and the interdental splint adjusted in view of causing greater pressure on the left ramus. On Dec. 1, 1917, a new vulcanite splint was made in an attempt to hold the left ramus in proper position. Dec. 3, 1917, the patient was operated on for repair of the scars of the left side of the face (Fig. 15). Feb. 26, 1918, the patient was evacuated to England.



Fig. 18.



Fig. 19.

Fig. 18.—Photograph showing lip sutured and supported by a splint shown in Fig. 17 (Case 5).

Fig. 19.—Patient at the time of evacuation to England (Case 5).

*Note.*—This record shows clearly the difficulties I experienced in holding the posterior fragment in position with intraoral appliances. An extraoral appliance of the Roger Anderson type would be the answer for such cases.

CASE 5 (J).—This patient was wounded on Nov. 6, 1917, and admitted to No. 26 General Hospital on Nov. 10, 1917, four days after injury. Examination showed an extensive wound of the chin and neck, and laceration of the lower lip and chin

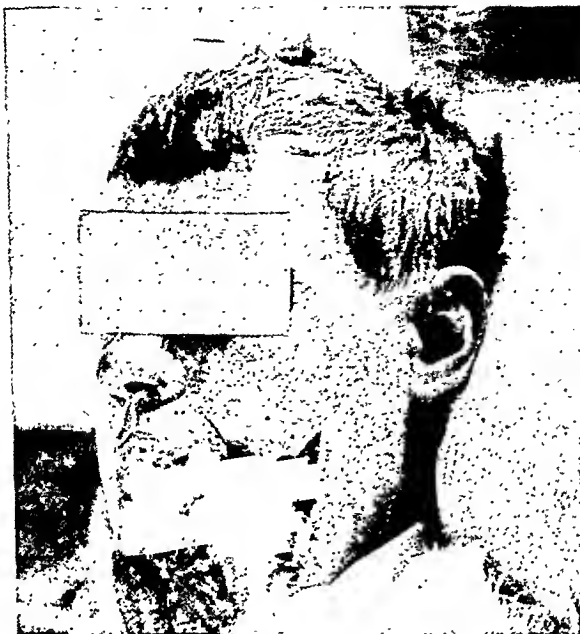


Fig. 20.—Photograph showing extensive laceration of the left side of the face, corner of the mouth, tongue, and lower lip. There was extensive comminution of the lower jaw involving the anterior section of the mandible. Several isolated fragments of bone were markedly displaced downward and backward (see X-ray, Fig. 21). In the upper jaw there was a fracture extending from the left cuspid to second molar region (Case 6).

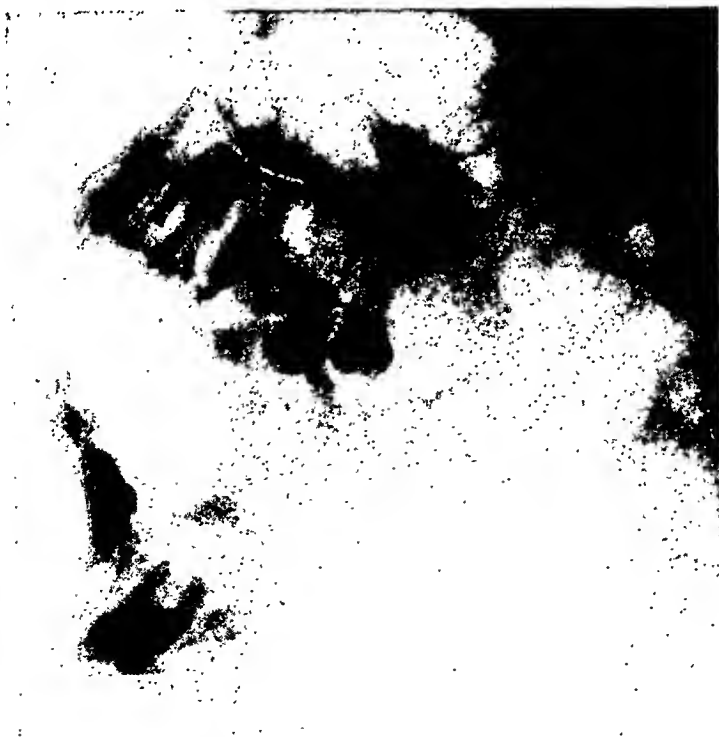


Fig. 21.—X-ray of Case 6. The comminution of the lower jaw extended from the angle on the right to the left second bicuspoid region, which was edentulous on that side. Anterior fragments of bone grossly displaced downward and backward toward the base of the tongue.

On May 9, 1917, fourteen days after admission, the patient was operated upon and the facial wound was sutured (Fig. 24). July 17, 1917, a new splint and chin piece was placed in position.

On Oct. 11, 1917, the patient was operated upon and the tongue was released and elongated by cutting its adhesions.



Fig. 24.



Fig. 25.

Fig. 24.—Fourteen days after admission, the patient was operated upon, and the facial wound was sutured (Case 6).

Fig. 25.—Appearance of patient at the time of evacuation to England (Case 6).

The remains of the mandible, which was brought to alignment, have consolidated. In this case also the mandibular arch is shortened anteroposteriorly, but the deformity is slight. At different times bony sequestra have been removed as they appeared or began to loosen. After the removal of the original lower appliance with the wire sutures, the chin showed a slight tendency to recede, and a screw was placed in the bone at about the median line. By means of an extraoral appliance the mandibular arch was again pulled forward. Upper and lower dentures have been supplied (Fig. 25).

#### REFERENCE

1. Kazanjian, V. H., and Burrows, Harold: The Treatment of Hemorrhage Caused by Gunshot Wounds of the Face and Jaws, *Brit. J. Surg.* 5: 126-150, 1917-1918.

## SOME DEFORMITIES OF THE FACE AND THEIR CORRECTION

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FACIAL deformities assume importance from several viewpoints, namely: functional, psychologic, cosmetic, vocational, and economic. Their correction has received periodic attention since early authentic surgical history. Rhinoplasties were done in India as early as 1000 B.C., and later in Italy, especially by the Branca family of Catania, and by Gasparo Tagliacozzi of Bologna in the sixteenth century. Interest was again aroused (1816 to 1847) by von Graefe and Dieffenbach during the time they were professors of surgery in the University of Berlin, and has continued to increase steadily.

Bone grafts were used to correct depressed nasal deformities in 1896. Rib cartilage transplants were used early in the twentieth century and continue to be more and more frequently employed.

Plastic and reconstructive surgery was given its greatest impetus during World War I. Since that time the technique has been refined and many of the methods then devised have been improved, and now play a still more important role in the surgical repairs necessitated by the present world-wide conflict.

The most frequent congenital deformities of the face are those associated with the various types and degrees of cleft lip and cleft palate. The methods which we prefer for the correction of such deformities have been considered in detail in several previous communications, thus they will be omitted here.

The splendid blood supply to all facial structures, and the mobility of the superficial tissues, make this area one especially well adapted to many types of plastic and reconstructive procedures.

Pigmented nevi may be major disfigurements, sufficient to exert dominant influences upon an individual's mental attitude, and upon the social and economic outlook. Fortunately most of them are amenable to surgical measures which make the areas relatively inconspicuous. The blue-black melanotic mole must not be irritated or manipulated, and, if it is to be removed, only a wide excision should be considered. In the brown or brownish hyperkeratotic or hairy varieties, however, lines of excision may with safety be made in or near the margins, the surrounding skin undermined and then approximated to cover entirely

A.



B.



C.



Fig. 1.—M. D., Case H-1144, aged 3 years. *A*, Papillary pigmented hairy nevus. *B*, Appearance two years later, after excision of frontal portion of nevus and use of a full-thickness skin graft, and partial excision over maxillary region, undermining margins and approximation without skin graft. *C*, Appearance one year later, five months after excision of remnants of pigmented area, and use of a calibrated split-skin graft, 0.012 inch in thickness, taken from the infrascapular region. The margins of the split-skin graft can be still further improved.

the raw area. This applies to medium-sized nevi. If the pigmented area is too large to permit this procedure for complete removal at one operation without undue tension on sutures, it may be removed by two or more such excisions, undermining of skin, and reapproximations by advancement of skin edges. The hairy pigmented area shown in Fig. 1 was so large that skin grafts, in addition to excisions, were used as described in the legends—a full-thickness graft in the frontal and temporal areas, and a calibrated split-skin graft to the infraorbital and cheek regions. Whenever possible, excision and advancement of the surrounding skin should be the method of choice, since skin grafted from some distant donor site never has exactly the same color and texture as that of the adjoining skin. Grafts from distant areas, however, are in many cases methods of necessity.



Fig. 2.—C. B., Case H-1272, aged 29 years. A, Lupus vulgaris which began in early childhood. B, Appearance nine months after excision of the skin of the entire involved area and the immediate use of a calibrated split-skin graft 0.014 of an inch thick, removed from the infrascapular region by means of a Padgett dermatome.

The case of lupus vulgaris shown in Fig. 2 began in very early childhood. Several types of treatment, chiefly radium, x-ray, and electric needles, were given throughout the intervening years without any appreciable improvement. A result which we regard as highly satisfactory was obtained by complete excision of the involved area and immediate skin grafting, using a calibrated skin graft 0.014 of an inch in thickness, taken from the infrascapular area by means of a Padgett dermatome. Six weeks after grafting, daily gentle massage of the area was begun. Examination nine months later showed that there had been a definite increase in the thickness of the graft and in the amount of subcutaneous fat.



There is a rather wide range of ear contours which come within the classification of normal. The size and shape of normal ears show hereditary characteristics in races and in families, which are as striking as are those found in the anterior facial features. Heredity also plays a part in some ear contours beyond the range of normal. Such abnormal contours may be unilateral or bilateral.

There are two classes of protruding or prolapsed ears which we believe should be treated by plastic surgery. First, those cases in which the deformity is so great that it interferes, or probably will interfere later, with the individual's success in securing satisfactory employment in the vocation of his choice. Second, those cases with less marked deformities, but occurring in sensitive individuals who are made so unhappy by being teased about their appearance that they tend to become



A.

B.

C.

Fig. 3.—P. B., Case H-1111, aged 7 years. A, Bilateral prolapsed protruding ears. Note deficiency of anthelix folds. B, Appearance eighteen months after reconstruction by the method shown in Fig. 4. C, Appearance nineteen months after secondary adjustment of superior portion of ears (aged 10 years). The striking change in personality is interesting.

self-conscious, secluded, and introspective. These deformities are chiefly due to insufficiency, or even absence, of the anthelix fold. To secure a satisfactory cosmetic result, an anthelix fold must be established. The result shown in Fig. 3 was gratifying not only because of the improvement in the appearance of the ears but also because of the definite transformation in personality obtained. The semidiagrammatic sketches and their legends (Fig. 4) give the technique used. Individual operators have devised their own modifications in technique according to the degree of the ear deformity being corrected, but all of the better operations are really founded upon the basic principles described by W. H. Luckett.\* With near-normal contour restored, and approximately a 30 degree cephalauricular angle established, the ear ceases to be conspicuous even though it may still be somewhat above the average size.

\*Luckett, W. H. Surg Gynec & Obst June, 1910

Marked congenital deficiencies of the nasal bones and the frontonasal processes of the maxillae are preferably corrected at 17 to 20 years of age by autogenous rib cartilage transplants (Fig. 5). If correction is attempted in *childhood* the *transplanted cartilage* usually does not in-

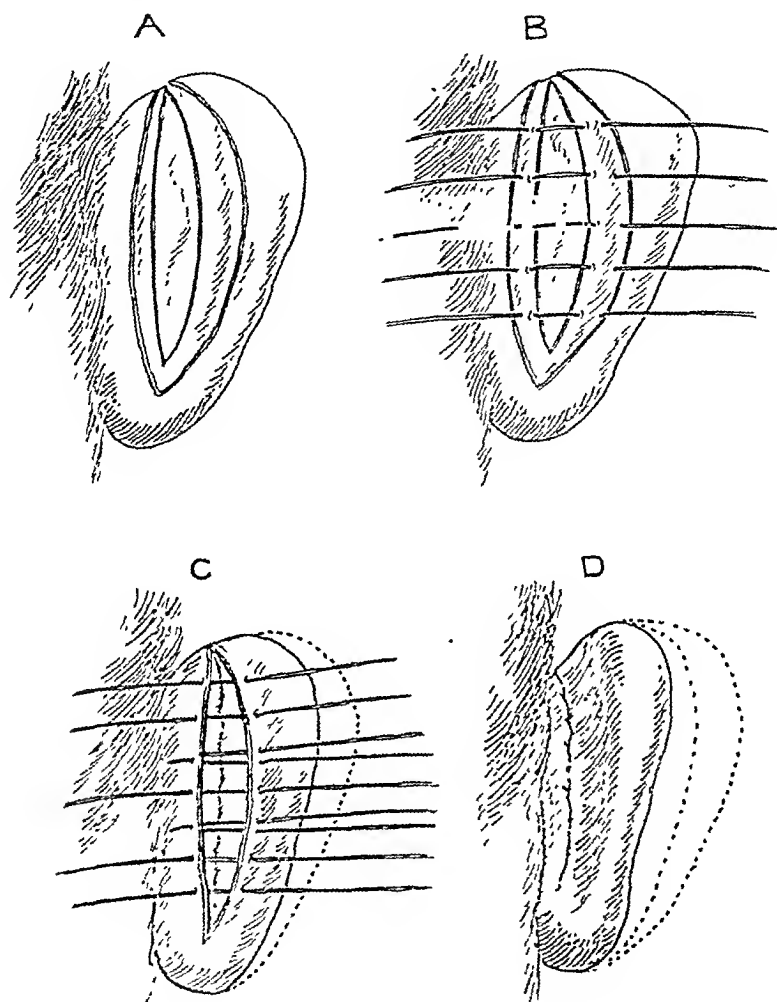


FIG. 4.—Semidiagrammatic sketches showing: A, The incisions used for removal of skin from the dorsal surface of the ear; the smaller ellipse shows approximately the amount of cartilage removed. B, Manner of inserting small catgut sutures through the perichondrium which, when tied, will force the cut edges of the cartilage anteriorly, forming an anthelix. C, Surfaces of cartilage have been approximated and skin sutures inserted; outer dotted line shows original position of the margin of the ear. D, Shows skin margins approximated, and the resulting outline of the ear. Outer dotted line marks original position; inner dotted line shows the position after approximating the cartilage.

crease appreciably in size and, consequently, as maturity is approached there is an increasing disproportion between the size of the transplanted cartilage and the size of the developed face. If, in some cases, early correction (Fig. 6) is deemed advisable because of marked introspection, or other psychologic reason, the patients and their parents should be told that a second operation may be necessary during late adolescence.

The use of curved cartilage chisels of proper sizes greatly facilitates obtaining the cartilage for transplanting, and placing the smooth convex surface upward helps to insure a well-formed dorsum nasi. The cartilage is preferably inserted through a columellar incision. Nasal

A.

B.



C.

D.

Fig. 5.—Case 6747, aged 17 years. A, Marked nonsyphilitic congenital deficiency of the nasal bones and frontonasal processes of the maxillae. B, Front view of A. C, Profile contour of nose four months after rib cartilage transplant. D, Front view of C.

depressions from destruction of the septal cartilage by infected septal hematomata in childhood, those from too extensive submucous resection of the nasal septum, and those from marked trauma are rather similarly corrected, but are more apt to require a supporting cartilagenous post

in the columella, extending from the undersurface of the anterior end of the dorsum transplant to the intermaxillary spine.

Excess convexities of the dorsum nasi are usually associated with some elongation and drooping of the nasal tip. Corrections are made by freeing the overlying skin and subcutaneous tissues from the cartilagenous bridge, and the periosteum from the bone to be removed, through an incision made within the superior portion of the anterior

A.

B.

C.



D.

E.

F.

FIG. 6.—D. W., Case II-1484, aged 5 years. A, Congenital nonsyphilitic deficiency of the nasal bones and frontonasal processes of the maxillae. B, Profile view of A. C, Contour of nose six months after autogenous rib cartilage transplant. D, Profile view of C. E, Contour of nose eight months after C. F, Profile eight months after D. Measurements and contour of nose indicate that the transplanted cartilage is growing as rapidly as the original nasal structures.

nares. In most instances we prefer to remove the excess convexity by means of numerous rasps in assorted shapes and sizes. Bone dust is removed with meticulous care; no rasp having been used is reinserted into the field of operation until it has been carefully brushed and cleansed in sterile water. In some instances saws are preferred in removing very large humps (Fig. 7). In most cases the width of the

new dorsum can be sufficiently narrowed by rasping the anterolateral portions of the frontonasal processes of the maxillae while they and the remnants of the nasal bones are being rounded and smoothened. If the

A.

B.



C.

D.

Fig. 7.—E. S., Case H-1737, aged 23 years. *A*, Profile showing convexity of dorsum and elongated drooping tip of nose. *B*, Front view of *A*, showing contour of nostrils. *C*, Profile six weeks after removal of excess convexity, shortening and elevating nasal tip. *D*, Front view of *C*, showing contour of nostrils.

width of the new dorsum is too great, the frontonasal processes may be divided with a saw, or narrow chisel, near their attachment to the bodies of the maxillae, and then pressed medially to the desired width. After

freeing the columella from its attachment to the septal cartilage by a through-and-through incision, a triangular section of the cartilage of the necessary size to secure the desired degree of shortening is removed and the columella then sutured to the septum in the position which properly elevates the tip.

A.

B.

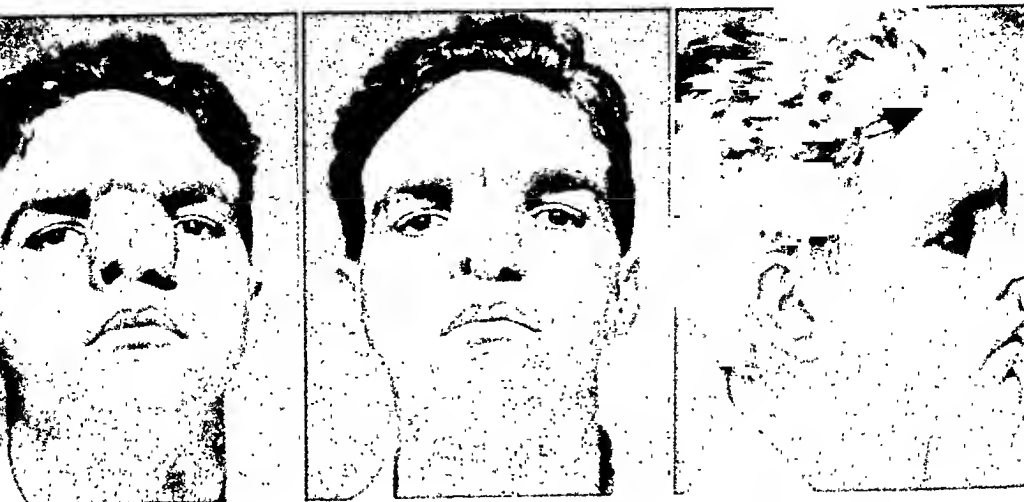


C.

D.

Fig. 8.—B. B., Case H-1502, aged 65 years. A and B, Rhinophyma, twenty-six years in developing. C and D, Appearance two months after multiple elliptical excisions, two operations, one month apart.

A *rhinophyma*, even of marked degree (Fig. 8), may be trimmed down to approximately normal size and contour by multiple, deep elliptical excisions, first removing the nodules, and then as much of the remaining

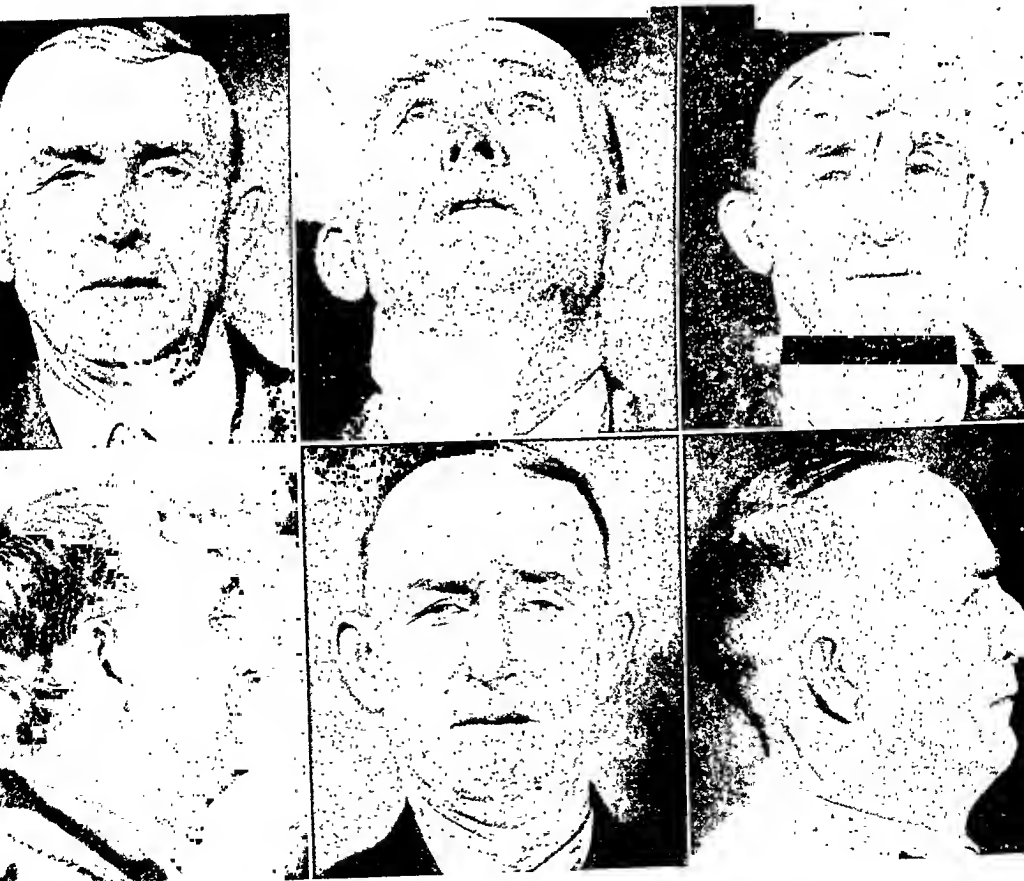


A.

B.

C.

Fig. 9. (For legend see opposite page.)



A.

B.

C.

D.

E.

F.

Fig. 10. (For legend see opposite page.)







Fig 11—R W, Case 5116, aged 34 years A, Opening er ing from the removal of a mole by radium seven months time the margins showed no tendency toward for maligne balance of lip seven months margins the lip were excised, converting it into a square Parallel incisions were carried from the lateral corners of the opening, through the full thickness of the lip and anterior portion of the cheek to the points indicated by the remaining scars The pedicle flap thus formed was advanced and sutured with meticulous care into new position, entirely closing the opening



Fig 12—H H, Case 8058, aged 45 years A, Cavernous hemangioma, present since infancy B, Appearance seven weeks after a two-stage operation. Excess tissue on skin surface first removed Conjunctival adjustment one month later

## SUMMARY

Several widely varying types of deformities of the face have been presented. The operative procedures used have been briefly described and the results obtained shown by illustrations from unretouched photographs.

In planning plastic reconstruction, one should carefully study the problems presented, endeavoring to visualize the ultimate result desired and to outline accordingly the various steps necessary in securing the best possible repair. Knowing the number of contemplated operations and the probable length of the intervals helps the patient in arranging adequate time for operations and convalescence.

Accuracy in outlining flaps, care in the preservation of the best possible blood supply, gentleness in handling tissues, and evenness in the approximation of subcutaneous tissues and skin margins, all tend to minimize scar tissue and thereby assist in securing the best functional and cosmetic results.

# THE REPAIR OF BONY AND CONTOUR DEFORMITIES OF THE FACE

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**D**ISPLACEMENT or loss of supporting structure of various parts of the face as a result of faulty development, injury, disease, or operation is accompanied by impairment of function and appearance. The principal facial deformities of developmental origin are cleft palate, unshapely contour of the external nose, and malrelationship of the upper and lower jaws resulting in undue prominence or recession of the chin, open bite, and other disturbances of occlusion of the teeth. Acquired deformities involve displacement or loss of supporting tissues (bone and cartilage), as well as overlying soft tissues, of varying extent, causing cosmetic or functional disturbance or both.

The means at our disposal for the replacement of lost or displaced supporting tissues following injury, disease, or operation are the use of soft tissue flaps, cartilage, bone, fascia lata, dermal grafts, and artificial appliances. Some bony defects accompanied by soft tissue loss can be satisfactorily repaired with soft tissue flaps alone when the bone loss involves an immovable part such as the hard palate or the outer surface of the maxilla. In the smaller palatal defects, sliding or pedicle flaps of oral or nasal mucous membrane may be used, while for the larger ones the introduction of pedicled flaps of skin may be necessary. Where a large bony defect is accompanied by loss of skin or mucous membrane on both sides, both epithelial surfaces should be replaced. Artificial substitutes are sometimes necessary to replace losses of bone and soft tissues of the upper jaw, being more satisfactory than surgical restorations under some circumstances. In some cases of palatal defect, for example, it may be possible to close the opening by surgical means, but the tissues thus repaired do not afford satisfactory attachment for artificial dentures. Artificial substitutes are occasionally preferable in external defects about the face where the extent of the tissue loss or the age of the patient militates against satisfactory surgical repair.

For the deeper and more extensive contour defects of the frontal region, nose, cheek, chin, or other parts of the face, costal cartilage forms the most satisfactory replacing substance. Several foreign materials (such as celluloid and ivory) have from time to time been advocated for this purpose. They have an advantage in that they are easily inserted without mutilating other parts of the body, but they are subject to all the disadvantages of any foreign body; for example, extrusion is

possible at any time. At one time paraffin was extensively used, but it should have no place in plastic surgery of the face, as it is difficult to control in injection, sometimes causing unsightly disfigurements, undergoes changes in shape, and may cause embolism and tumor formation. In late years, vitallium and, more recently, tantalum have been used with encouraging results. Transplanted bone as a support for the bridge of the nose is employed successfully by some surgeons. We prefer costal cartilage for this purpose, because it rarely undergoes absorption when imbedded in soft tissues and is not so susceptible to infection as bone. Costal cartilage is not difficult to obtain in almost any quantity desired and is easily trimmed to suitable size and shape. While living autogenous costal cartilage is undoubtedly preferable to any other, in recent years many operators have successfully used preserved cartilage from other individuals and even from cadavers. The use of preserved cartilage has the advantage in that unlimited quantities are available, and the patient does not have the inconvenience of the chest operation added to that on the face. Living autogenous cartilage, on the other hand, is less likely to undergo changes after transplantation. Costal cartilage has a tendency to change shape by curling, resulting in an unsightly deformity. To overcome this, Gordon New exposes the cartilage after removal to live steam for a minute or two. This causes the maximum amount of curl to take place immediately, after which the cartilage can be trimmed to proper size and shape and no further changes will occur. Of course, the steaming destroys the vitality of the cartilage. Costal cartilage does not form a firm union with bone; hence, it cannot effect a stable restoration of continuity in a movable bone such as the mandible. For filling gaps to restore continuity of the mandible, bone transplants alone are satisfactory.

Displacement of bony structure alone, or combined with loss of substance, may be responsible for facial deformity. In some cases of this type, correction of the deformity may be attained by mobilization of the displaced portion of bone and replacement in normal position. This is not always possible, especially where the displacement is of long standing, such as in the case of an old depressed fracture of the nasal or malar bones. Here, correction is more satisfactorily brought about by building out the contour with added bone or cartilage at the site of the depression.

After a fracture of the mandible, with or without loss of substance, union may take place with shortening at the site of fracture, resulting in facial asymmetry and functional disturbance. The same sort of deformity may follow loss of a portion of the mandible from necrosis or operation for removal of a neoplasm. Here, the displacement first must be corrected by osteotomy at the site of malunion or division of adhesions holding displaced fragments in a contracted position, and by reduction of fragments to a position as normal as possible, followed later by

bone grafting if a gap remains that is too wide to be bridged by spontaneous bone regeneration.

Osteotomy of the mandible may be carried out with a narrow chisel at the site of malunion but is usually done with less trauma by means of a Gigli saw. A small incision through the skin, not more than one-half inch long, is made to the lower border of the mandible at the point of malunion. A full-curved pedicle needle is passed through the incision, close to the inner surface of the bone, until the mucous membrane of the mouth is pierced. By means of a wire through the eye of the needle, a Gigli saw is carried on the inner surface of the bone with one end in the mouth and the other emerging through the skin incision. The mandible is then sectioned with the saw from the inner side out through the fracture line. The skin incision is sutured and usually heals by first intention, leaving practically no visible scar. The bone fragments are now reduced and treatment is as for a recent fracture, with or without loss of substance. The method of fixation of the fragments to be used depends upon the availability of teeth. In most patients with sufficient teeth in each fragment and in the upper jaw, we find that simple wiring methods, such as the eyelet or the arch bar methods, are most easily applied and give adequate fixation. The more elaborate splints are reserved for patients in whom teeth are not adequate for use of the simpler methods.

Bone grafting is sometimes employed for repairing defects of the cranium and contour losses of various parts of the face, but its most frequent use is in restoring continuity and replacing losses of substance of the mandible resulting from trauma, necrosis, or resection for treatment of disease.

Statistics from World War I indicate that about 11 per cent of gunshot fractures result in nonunion and require bone grafting. The nonunion is caused principally by the large loss of bone substance and inability of the repair mechanism to bridge the gap when the collapsed fragments are drawn apart and fixed in proper position. The loss of bone is not so often due to primary destruction as to extensive shattering followed by infection and necrosis. In comminuted fractures, proper early fixation and conservation of viable bone fragments will do much to render bone grafting unnecessary later.

The object of treatment in patients with loss of substance of the mandible from whatever cause is primarily restoration of the function of mastication. This is attained by restoring the normal occlusion of the remaining teeth and stabilizing the jaw by filling in the lost continuity of the bone. A secondary objective is the building out of contour of the face for improvement in appearance. In patients with loss of substance it is very rarely desirable to obtain union by bringing the ends of the fragments together, sacrificing the occlusion of the teeth. This results in a crippling of the masticatory function and an increase in the external deformity.

Where bone grafting is contemplated, the preoperative treatment of patients with losses of substance of the mandible is as follows: removal of all septic foci, reduction, and fixation in such a position that the normal occlusion of the remaining teeth is restored. Septic foci include roots of teeth projecting into the area of lost substance, other teeth showing evidence of periapical or periodontal disease, bony sequestra, metallic foreign bodies, and infection in the adjacent soft tissues. No operation to restore the continuity of the bone should be attempted until all sources of infection have been removed and until at least three months have elapsed after all sinuses and septic wounds have healed.

Reduction is brought about in cases of nonunion by manipulation, followed immediately by the application of wires to fix the upper and lower teeth together, or, if the existing teeth are not adequate for this method, then the more elaborate interdental splints are used. Where the bone fragments are not freely movable and cannot be reduced by manipulation before application of measures of fixation, owing to the presence of fibrous adhesions, it becomes necessary to sever these adhesions at a preliminary operation, apply the fixation, and then wait several weeks for healing of the soft tissues to occur before performing the bone-grafting operation. As long as there is any possibility of contamination of the wound with oral secretions, bone grafting is contraindicated. In nearly all cases of this type the preliminary operation requires cutting through the oral mucosa, which renders absolutely necessary postponement of the bone grafting until complete healing has occurred.

*Types and Methods of Bone Grafting in the Mandible.*—In many of the patients after World War I restoration of continuity was brought about by a pedicled graft from the mandible itself, the pedicle consisting of attached muscle. This method was first described by Bardenheuer in 1893 and was popularized by Cole, of London. We have not used this method recently because we found that it produces undue distortion of the soft tissues of the floor of the mouth and neck and is not suitable for large losses of bone substance, especially in the region of the angle and ascending ramus of the mandible. We consider also that the cortex of the tibia is not very suitable as a source of bone graft for the mandible because of its extreme density and consequent resistance to penetration of new blood vessels in the process of consolidation. Also, fracture of the tibia after removal of a thick graft is not unknown. Rib grafts have sometimes been used for these defects but are usually too thin. During the past twenty-four years we have limited ourselves to two methods, each having fairly definite indications; namely, the osteoperiosteal graft from the tibia and the graft from the crest of the ilium.

1. *The Osteoperiosteal Method of Delagenière:* The osteoperiosteal graft contains all the elements necessary for osteogenesis, is flexible, and is easily adjustable to the size and shape of the defect. The tech-

nique of removal and insertion is simpler than that of any of the other methods. It causes no disability in the leg. It requires longer to obtain complete consolidation than by other methods, and no dependence, of course, can be placed on the rigidity of the graft itself for maintenance of the mandibular fragments until consolidation has occurred. While this form of graft can be used for losses of substance of the mandible of almost any extent and any position, we usually reserve it for defects of 2 cm. or less and for patients in whom the external contour of the face shows little or no deficiency. It is also to be selected for use in children, because the crest of the ilium shows very little ossification before 15 or 16 years of age.

2. *Graft From Crest of Ilium:* A graft from the crest of the ilium was first used in Germany by Lindemann and was the method of choice also of Gillies and his co-workers at the Queen's Hospital at Sidcup, England. This type of graft is preferred if the gap in the mandible exceeds 2 cm., and especially if the external contour of the face shows the deficiency. The crest of the ilium furnishes a large piece of bone of porous structure closely resembling that of the mandible, it is easily penetrated by new vascular supply, and it can readily be cut to suitable shape. The disability produced by removal of the graft is quite temporary and the danger negligible.

The technique of grafting the mandible by either of these methods has been fully described elsewhere, so further space will not be taken up with it here, except to say that exposure and preparation of the mandibular fragments are done before removal of the graft from the donor site in order that the size of the graft required may be determined and also on account of the possibility of opening into the mouth while preparing the bed for the graft, an accident that would render useless the application of the graft at this time. Another reason for this order of procedure is the desirability of protecting the viability of the graft by placing it in its new position as soon as possible after removal from its original site.

Postoperatively, fixation of the jaws must be maintained until consolidation is well advanced; that is, for at least eight weeks. Regeneration may be checked by x-ray examination at monthly intervals, but the final test of consolidation is by clinical examination after disconnecting the upper and lower teeth.

The following cases illustrate several of the features mentioned in this article:

CASE 1.—In Case 1 is illustrated protrusion of the mandible. The patient was first seen at the age of 18 years in consultation regarding a protrusion of the mandible which had gradually become more noticeable with growth. Physical examination revealed nothing having any bearing on this condition. The lower anterior teeth were about three-fourths of an inch in front of the corresponding upper teeth, and only the last molars were in occlusion (Fig. 1). The forward position of the mandible caused a very noticeable prominence of the chin (Fig. 2). There was

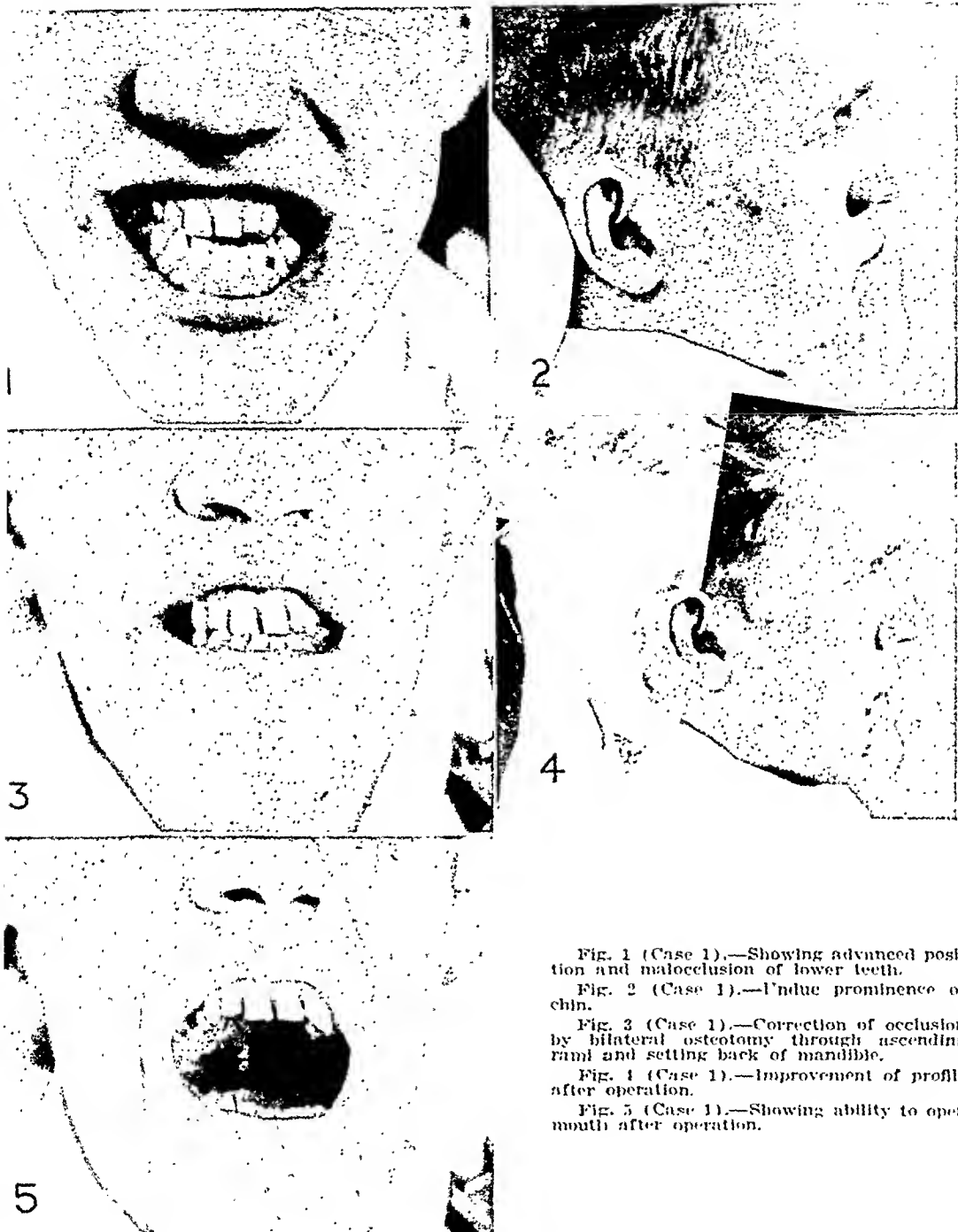


Fig. 1 (Case 1).—Showing advanced position and malocclusion of lower teeth.

Fig. 2 (Case 1).—Undue prominence of chin.

Fig. 3 (Case 1).—Correction of occlusion by bilateral osteotomy through ascending ram and setting back of mandible.

Fig. 4 (Case 1).—Improvement of profile after operation.

Fig. 5 (Case 1).—Showing ability to open mouth after operation.

marked interference with the function of mastication. Impressions were made of the teeth and plaster casts prepared to determine whether a satisfactory dental occlusion could be obtained by setting the mandible back. This being found possible, an operation was decided upon. Preceding the operation, half round arch bars were



applied to the upper and lower teeth to serve for postoperative fixation. Under intratracheal ether anesthesia introduced through the nose, each ascending ramus of the mandible was sectioned horizontally by a Gigli saw introduced through small skin incisions behind and in front of the ramus by means of a modified Blair pedicle needle. This permitted the main part of the mandible to be slid back on these cuts, bringing the lower teeth into good occlusion with the upper. The upper and lower teeth were then fixed in occlusion by connection of the arches on the teeth with tie wires. Immobilization was maintained for six weeks, after which union in the new position was found to be fairly solid. The wire fixation was replaced by intermaxillary elastics for about ten more days, the patient being then discharged. Figs. 3, 4, and 5 illustrate the result of the operation.

CASE 2.—In Case 2 is illustrated the use of costal cartilago to restore contour in the frontal region. The patient sustained a crushing injury in an automobile accident with loss of bone in the left frontal region. This left him with a marked depression, the overlying skin being intact except for a vertical scar (Fig. 6). An



Fig. 6 (Case 2).—Marked depression left frontal region due to loss of bone.

Fig. 7 (Case 2).—Elimination of depression by implantation of costal cartilage.

incision was made through the old scar line and the skin on each side undermined over the depressed area to form a pocket. Into this was inserted a piece of autogenous costal cartilage of suitable size and shape to restore the contour of the forehead. The skin wound was closed with interrupted silk sutures (Fig. 7).

CASE 3.—In Case 3 is illustrated a contour defect of the right frontal region with loss of both soft tissues and bone. The patient was thrown from a moving automobile into the road, where he landed on his face, resulting in a compound comminuted fracture of the right side of the frontal bone with avulsion and laceration of overlying soft tissues. Fig. 8 shows the condition of the patient several months later when the defect was ready for definitive repair. On the right side of the forehead there was a broad deep defect, involving the bone in part, covered with healed scar. One small area had been covered with unsightly pinch grafts, no doubt to hasten healing. There was a small opening into the frontal sinus. The extent

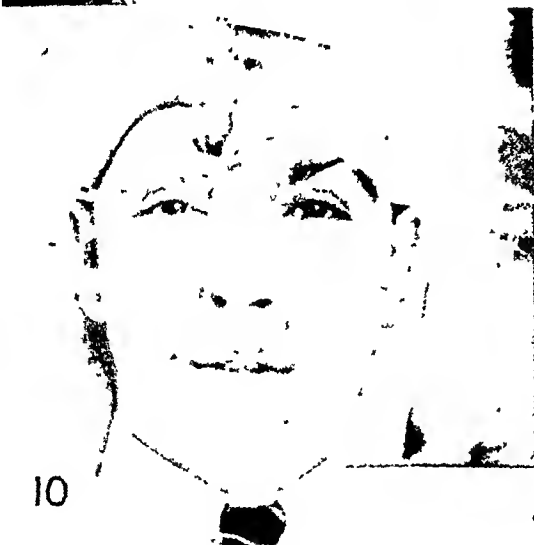
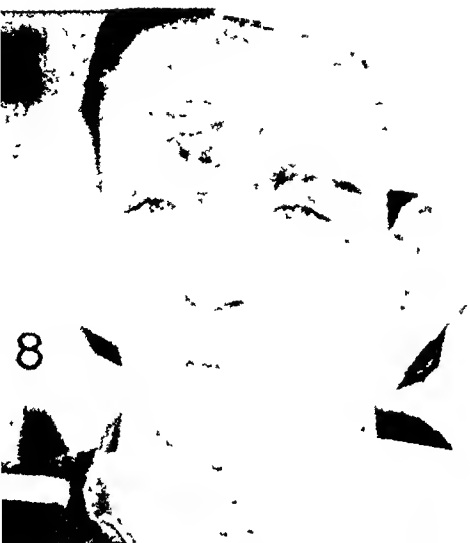


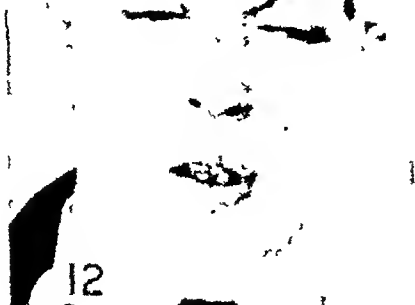
Fig. 8 (Case 3).—Healed deformity of right frontal region. Loss of bone and soft tissue with opening into frontal sinus.

Fig. 9 (Case 3).—Stage in transfer of tube pedicle flap from clavicular region for repair of forehead defect.

Fig. 10 (Case 3).—Another stage of transfer of flap to forehead.

Fig. 11 (Case 3).—Another stage of transfer of flap.

Fig. 12 (Case 3).—Flap spread out to cover forehead defect.





14



16

Fig 13 (Case 4).—Extensive brown hairy nevus of left side of face

Fig 14 (Case 4).—Tube pedicle flap on abdomen with one end attached to wrist for later transfer to face

Fig 15 (Case 4).—Tube pedicle flap from abdomen carried to left side of face on right wrist

Fig 16 (Case 4).—Result after excision of growth and covering of raw area with tube pedicle flap from abdomen

of the area precluded repair by sliding flaps from the surrounding frontal region. The depth of the defect and the opening into the frontal sinus rendered a free skin graft unsuitable. Consequently, a tube pedicle flap from the right clavicular region was transferred to the forehead in several stages at three-week intervals. The procedure is shown in Figs. 9, 10, and 11. Fig. 12 shows the final stage of the flap transfer. Later, the eyebrow was restored by a free full-thickness graft from the scalp.

CASE 4.—Brown hairy congenital nevus of face had existed since birth in the patient in this case, and the boy was presented for treatment at 6 years of age. The lesion was dark brown in color and slightly elevated; the surface was rough and covered for the most part with a heavy growth of furlike hair. It involved the entire left cheek, extending into the temporal region, the entire lower eyelid and part of the upper eyelid, the left side of the nose, including the ala, and passed over on to the right side of the nose (Fig. 13). These growths are not radio sensitive, and surgical excision in this case offered the only possibility of successful treatment. Three ways of repairing the defect were considered: (1) Multiple partial excision. In growths and scars involving a moderate area in the cheek, this method is excellent in that it gradually advances the surrounding healthy skin and succeeds in covering the area with skin of texture and color normal for the part, with a very small amount of scarring. In the present case, the extent of the area involved precluded the use of this method. (2) Complete excision, followed by immediate application of a split-skin graft. This was also rejected, partly because of the inability of a free graft to furnish sufficient contour, and also the appearance of the grafted area would leave too much to be desired. (3) Use of a pedicled flap. This method was finally selected, because it supplied sufficient contour, with a better chance of complete take of the transplanted tissue. It was realized that there would be difficulty in matching the rest of the face in color and texture. At the first operation a tube pedicle was prepared on the left side of the abdomen from a strip of skin and subcutaneous tissue three inches wide and eight inches long. Three weeks later the lower end of the tube was cut loose and sutured into a raw area exposed by turning a flap on the radial side of the right wrist (Fig. 14). Restriction of movement during healing was adequately managed by means of adhesive plaster strips. The next step, three weeks later, consisted in disconnecting the upper end of the tube from the abdomen and carrying it up on the wrist to the face where it was sutured into a raw area in the left temporal region created by excision of part of the nevus. Sufficient fixation for good healing was obtained by holding the arm in the Velpeau position with adhesive plaster and a bandage. Plaster of Paris was unnecessary (Fig. 15). After a further three-week period the flap was disconnected from the wrist and the tubed portion opened out and spread to cover the raw area on the face after excision of the major portion of the growth. Two or three further operations were necessary to smooth edges here and there, and a full-thickness preauricular skin graft was applied to the left lower eyelid. Although there is some discrepancy in color and texture of the skin of the flap as compared to the rest of the face, it is hoped that with time this will become less noticeable (Fig. 16).

CASE 5.—In this case is illustrated the deformity of contour of the face and interference with function due to malunion in a fracture of the mandible. The patient was edentulous and sustained a fracture of the left ascending ramus of the mandible. Owing to the absence of teeth, no reduction or fixation was applied after the injury, with the result that his fracture united in malposition, the left side being shortened. This caused the chin to deviate to the left. The mouth opening was greatly restricted, and this and the malocclusion of the upper and lower alveolar arches prevented the wearing of artificial teeth (Figs. 17 and 18). Correction was

carried out in the following way: An osteotomy was performed at the site of the fracture in the left ramus of the mandible. This permitted the main portion of the lower jaw to be carried to the right and the chin to the midline position. Fixation by means of the teeth being impossible, a circumferential brass wire was passed around each fragment and the ends brought out through small skin incisions and attached to metal bars (coat hanger wire) coming down from a plaster of Paris head cap (Fig. 19). By this means the fragments were held in normal relationship. Fig. 20 is from a radiograph made at this time and shows the circumferential wires and also the gap created between the fragments after they were properly reduced by the osteotomy. After waiting for about six weeks for healing from this preliminary operation, the gap in the mandible was filled with a bone graft from the crest of the ilium (Fig. 21). Consolidation took place in eight weeks, the circumferential wires and headcap were removed, and the patient was then able to have full upper and lower artificial teeth made, with which he could masticate (Fig. 22).

CASE 6.—In this case is illustrated a unilateral defect of the mandible with retraction of the chin. The patient in this case was an 18-year-old boy, who, when 8 years of age, had had a resection of several inches of the left side of the mandible for a tumor, reported to be a sarcoma. Later, two attempts were made in another city to restore the defect in the mandible by rib grafts, which were unsuccessful. Examination showed the typical deformity resulting from a defect of one side of the mandible. There was marked shortening on the left side, causing the large segment of the lower jaw, with its teeth, to be drawn over toward the left, attached by fibrous tissue to a short left segment consisting of the ascending ramus and the coronoid and condyloid processes. There were no teeth on the left side beyond the first incisor, and the remaining mandibular teeth had no relationship with the upper teeth, being drawn backward and inward. He could open his mouth widely, but there was a marked deviation of the lower jaw to the left (Fig. 23). The profile showed marked recession of the chin. There was a dense external scar adherent to the bone on the left side (Figs. 24 and 25). Fig. 26 is from a radiograph showing preoperative condition of the bone on left. Correction of this case involved several steps:

1. Division of fibrous adhesions between the ends of the mandibular fragments and remains of the rib graft on the left side to allow the main portion of the lower jaw and teeth to be carried to the right and forward into more normal position. After the adhesions had been severed it was possible to bring the lower teeth into fairly good occlusion with the upper and hold them there by means of arch wires. This interdental fixation was supplemented by a circumferential wire around the symphysis, forward traction on the chin being maintained by attachment of the wire passing around the bone to a bar coming down in front of the face from a plaster of Paris headcap. This forward traction was maintained for about three weeks, after which fixation was continued by the wires attached to the teeth.

Fig. 17 (Case 5).—Deviation of chin to left due to malunion of fracture of left ramus of mandible.

Fig. 18 (Case 5).—Restriction of opening of mouth and malrelationship of edentulous upper and lower alveolar arches rendering impossible insertion of artificial dentures.

Fig. 19 (Case 5).—Fixation of fragments after osteotomy by circumferential wires and plaster headcap.

Fig. 20 (Case 5).—Radiograph after osteotomy showing gap in bone on left side and circumferential wires.

Fig. 21 (Case 5).—Radiograph showing gap in mandible filled with graft from crest of ilium, bringing about stabilization and restoration of length.

Fig. 22 (Case 5).—After restoration of correct position of jaw and increase in mouth opening, permitting insertion of artificial dentures.



Figs. 17-22. (For legends see opposite page.)

2. Replacement of the dense scar over the operative field by good skin and subcutaneous tissue. This was accomplished by transplantation of a tube pedicle flap from the left clavicular area.

3. Restoration of the length and continuity of the left side of the mandible by a bone graft. Three months after the first operation, the wounds from these preliminary operations having healed, a graft two and one-half inches in length and



Fig. 23 (Case 6).—Marked deviation of lower jaw to left on opening mouth due to loss of bone on left side.



Fig. 24 (Case 6).—Right profile before treatment showing backward position of chin.

Fig. 25 (Case 6).—Left profile before treatment showing adherent scar.

comprising the entire width of the crest of the left ilium, was removed with a meta carpal saw, and after exposure of the ends of the separated mandibular fragments, it was inserted in the gap, being fastened to each fragment by brass wire sutures passed through holes drilled in the bone (Fig 27). This operation was followed by some low grade suppuration, which stopped after removal of one of the suture wires two months later. Shortly after this, the wire fixation on the teeth was discontinued, and union of the graft with stabilization of the jaw was found to be complete.

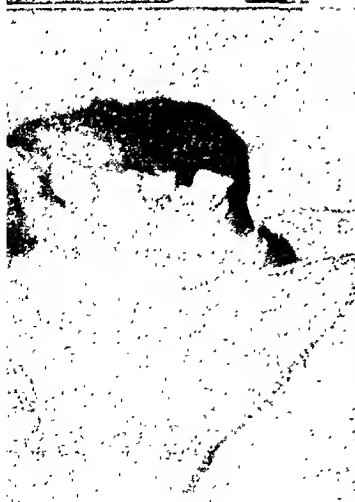
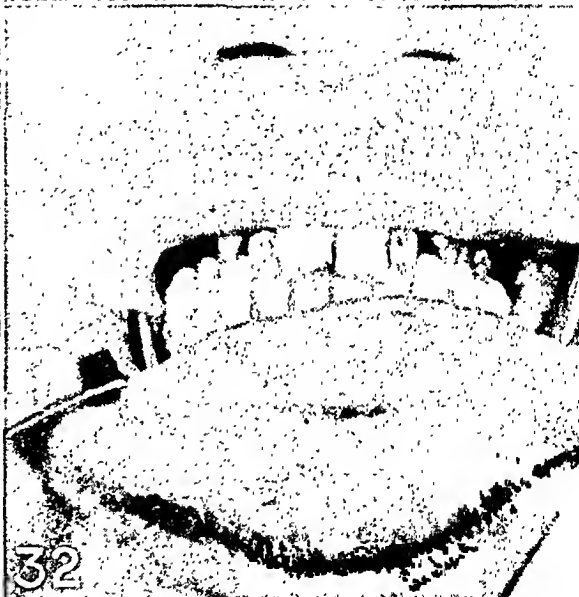
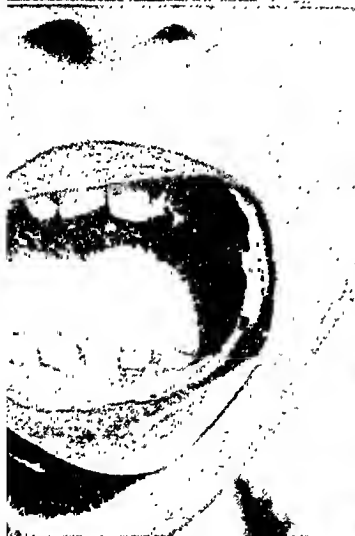
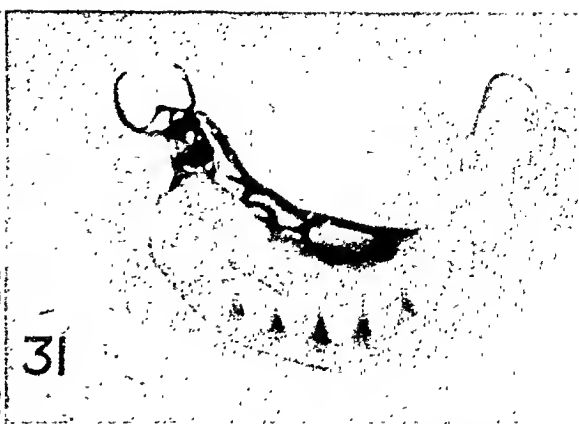
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Fig. 26 (Case C) —Radiograph showing defect in left side of mandible and remains of unsuccessful rib graft.

Fig. 27 (Case C) —Radiograph showing restoration of continuity and length of left side of mandible by graft from crest of ilium.





Figs. 28-33. (For legends see opposite page.)

Figs. 28 and 29 show the occlusion of the teeth at that time and also the mouth opening, with better central position of the mandible.

4. Additional prominence to the chin and restoration of occlusion by provision of artificial lower anterior teeth. Four months after the bone-grafting operation, the mucous membrane in the vestibule of the mouth beneath the anterior mandibular teeth was divided by an incision extending from one premolar region to the other, and the soft tissues were separated from the periosteum over the anterior surface of the mandible almost down to its lower border. This created a deep pocket in the soft tissues behind the lip, which was then lined with a split-skin graft supported on a mold of dental impression compound. This was held in position for several days by circumferential sutures. After removal of the compound, the pocket was found to be lined with skin (Fig. 30). The patient then had a partial denture\* constructed



Fig. 31 (Case 6).—Improved profile after completion of treatment. Compare with Fig. 24.

of acrylic material, which fitted over the natural lower anterior teeth and which occluded well with the upper teeth. An extension from the appliance passed down into the skin-lined pocket to build out the chin to a considerable extent. The patient's jaw is now stable, with normal opening and closing, and with the appliance in place he is able to masticate any kind of food; also, the profile is greatly improved (Figs. 31, 32, 33, and 34).

CASE 7.—In this case is illustrated a defect of the cheek and palate resulting from radiation treatment for carcinoma of the upper jaw. A female, single, aged 25, had been first treated three years previously by x-rays and radium for a lesion of the upper right jaw, diagnosed as carcinoma of the right maxillary sinus, verified by biopsy. As a result of the treatment, the soft tissues of the cheek sloughed, ex-

\*Dr. Frank A. Fox, University of Pennsylvania Dental School, constructed the denture.

Fig. 28 (Case 6).—Improvement in occlusion of teeth after bone graft.

Fig. 29 (Case 6).—Disappearance of deviation of mandible to left on opening mouth after stabilization of jaw by bone graft. Compare with Fig. 23.

Fig. 30 (Case 6).—Pocket between bone and soft tissues of chin lined with split-skin graft.

Fig. 31 (Case 6).—Artificial appliance to supply missing teeth and build out prominence of chin (Courtesy of Dr. Frank A. Fox).

Fig. 32 (Case 6).—Artificial appliance in place, mouth closed, showing good occlusion of teeth.

Fig. 33 (Case 6).—Artificial appliance in place, mouth open.

posing the necrotic malar and maxillary bones on the right side (Fig. 35). No evidence of the original malignancy remained, but the surrounding skin showed marked atrophic changes. At the first operation a large sequestrum was removed, comprising most of the right malar and maxilla including the palatal and alveolar processes, and the teeth attached to it, as well as the septum of the nose. This left a large opening in the right cheek, into the maxillary sinus and nose, and a defect comprising the entire right side of the hard palate. This caused marked impairment of speech. At the time the dead bone was removed, a long tube pedicle was prepared from the right anterior axillary fold down to the groin to be used later to repair



Fig. 35 (Case 7).—Extensive radiation necrosis of right malar and maxilla with destruction of soft tissues of cheek.

Fig. 36 (Case 7).—Opening through right cheek into maxillary sinus and nose after removal of dead bone. Tube pedicle flap from axilla to upper part of chest, to be used later for repair of openings in face and mouth.

the face. Fig. 36 shows an intermediate transfer of the tube pedicle to the upper part of the chest and the defect in the cheek. After the first operation it became necessary to wait several months before attempting repair of the facial defect, until all infection had cleared up and remaining dead bone had come away. Pathologic examination of tissue removed from the edges of the defect and from the cavity from time to time showed no persistence of the malignancy. Eight months after the first operation, the distal end of the flap was severed from the axillary region and, after freshening the edges of the opening in the cheek, the end of the tube was flattened out by excision of intervening fat to create two surfaces of skin, one being sutured to the edges of the defect facing in to replace the lining of the maxillary



Fig. 37 (Case 7).—End of tube pedicle from chest sutured to cover opening in cheek.

Fig. 38 (Case 7).—Other end of tube pedicle sutured to edges of defect in hard palate.

Fig. 39 (Case 7).—Defect in hard palate completely closed by skin flap.

Fig. 40 (Case 7).—Artificial teeth inserted.

sinus and the other facing out to replace the lost external skin (Fig. 37). Considerable difficulty was experienced in getting the skin of the flap to heal well to the poorly nourished skin surrounding the defect. Four months elapsed, therefore, before it was considered safe to proceed with the next stage. Then, the flap was cut loose from the chest and the free end was in turn thinned out to form two skin surfaces, which were then sutured into the palatal defect, forming upper and lower layers. In order to introduce the end of the flap into the mouth it was necessary



Fig. 41 (Case 7).—Present external appearance subject to further improvement by thinning out of flap, smoothing of edges, etc

to divide the right side of the upper lip, and this was later repaired. Fig. 38 shows the tube, forming a loop, with one end on the cheek and the other in the palate. After a few weeks it was noted that the opening in the palate had been completely closed by the skin flap. The loop was then divided where it emerged from the mouth. The freshened ends were trimmed to fit the remaining free edges of the cheek and mouth defects, respectively, and sutured in place. Later, several minor operations were done to thin out and shape the cheek flap, and a piece of costal cartilage was inserted beneath the lower eyelid to support the right eyeball. An upper artificial denture\* was made, enabling the patient to masticate food with satisfaction. The marked defect in speech was immediately overcome by operative repair of the palate, and her appearance was greatly improved (Figs. 39, 40, and 41).

\*See footnote on page 71.

# EVALUATION OF PEDICLE FLAPS VERSUS SKIN GRAFTS IN RECONSTRUCTION OF SURFACE DEFECTS AND SCAR CONTRACTURES OF THE CHIN, CHEEKS, AND NECK

GUSTAVE AUFRICHT, M.D., NEW YORK, N. Y.

THE treatment of skin defects constitutes an important phase in plastic surgery. In this paper communication we are mostly concerned with the treatment of extensive surface defects and disfigurements of the chin, cheeks, and neck. Injuries caused by fire of clothing around the neck are quite common on children, especially of poorer families where supervision of the playing child is often neglected. Another common injury in this locality is the x-ray burn, resulting from excessive x-ray treatment formerly given in cases of hypertrichosis. Injuries caused by acid are quite similar to those caused by fire. Undoubtedly the great variety of war casualties also produce many surface injuries in this region.

In general, it can be stated that regardless of the cause, the principles of reconstruction are very much the same. The issue of first importance in granulating wounds after extensive injuries is the quick epithelization. The cosmetic effect is rather of secondary importance. Undoubtedly the most advantageous treatment is early skin grafting.

The treatment of patients with old scars and scar contractures presents an entirely different problem from those with fresh injuries and defects. Extensive burn scars of the face where the scar is superficial, soft, and smooth, offers a real dilemma to the surgeon. I have in mind scars caused by second degree burns where only the superficial layers of the epidermis are destroyed. One must realize that the transplanted skin also has its esthetic shortcomings and is far from being a perfect match to the normal skin. Therefore, in mild cases of scarring, it is of paramount importance to know our limitations and advise against operation.

~ If one or two contracting, scarry bands are present, shifting of the skin with a Z plastic is sufficient in suitable cases.

In mild cases of x-ray burn where no breaking down of tissues or ulceration is present and there is only the typical atrophy and discoloration of the skin, it is safer to discourage transplantation. A heavy, colored, make-up cream will give more satisfaction. There is time for surgical intervention if and when the breaking down of the atrophied skin takes place.

Extensive defects of the chin, cheeks, and neck, heavy hypertrophic scars causing distortion and functional disturbance, and crippling contractures are cases where plastic surgery can offer real relief.

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Severe x-ray or radium burns with ulceration, considerable pain, and danger of malignant changes are also cases in which conservative treatment must cease in favor of radical surgery.

Considering the favorable experience with *tubed* flaps in comparison with *open* flaps, there is seldom an occasion for the use of open flaps. Where large surfaces of skin need to be transplanted, the advantages of the tubed flap, or "skin tubes," are: (1) the protection of the wound surfaces from exposure to infection; (2) the small amount of fibrous tissue formation, therefore its pliability; and (3) the easy stages and long intervals between operations.

The skin tube can be moved repeatedly; therefore it can be taken from a site distant from the defect if necessary; or it can be attached to an intermediary host, such as the hand (Fig. 4, *H*).

Skin tubes can be formed on practically any part of the body. For the repair of extensive defects, the most advantageous sites are: (a) axilloabdominal; and (b) transverse or oblique abdominal (transferred usually via hand). In case of necessity, (c) acromiopectoral, and (d) dorsal tubes can also be used.

Very long tubes can be prepared, with proper caution, due to its well-protected blood supply. It is possible to make a tube so long that the skin of the lower abdomen can reach the face in one shift (Fig. 1, *G* and *J*).

In selecting the donor site, the following points must be considered:

1. The skin of the donor area should be a good esthetic match with the locality of the defect in color, texture, and thickness.
2. An adequate amount of skin should be obtainable.
3. It should be relatively convenient to transfer from the donor area to the defect.
4. The secondary scar of the donor area should be hidden, and should not cause functional disturbance.

Careful analysis should be made of the size and contour of the defect. The inexperienced surgeon often tends not to provide large enough flaps. To overcome this, he tries to suture under tension which leads to necrosis.

The following points relative to the technique of forming the tubed flap are important:

1. Strict surgical asepsis.
2. Thorough hemostasis within the tube to avoid hematoma.
3. The length of the flap should not exceed three times its width, preferably two and one-half times. If longer tubes are necessary, they should be prepared either in sections with intermediary pedicles (Fig. 1,

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Fig. 1.—*A*, *B*, and *C*, Preoperative photographs of patient with burn scars of chin and lower lip caused by fire of clothing. *D*, *E*, and *F*, Postoperative photographs after reconstruction of chin and lower lip with axilloabdominal skin tube. *G*, Axilloabdominal skin tube. *H* and *I*, Showing attachment of temporary intermediary pedicle of axilloabdominal skin tube. *J*, Axilloabdominal skin tube attached to face.



Fig. 1. (For legend see opposite page.)



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Fig. 2. (For legend see opposite page.)

2. Large transplants have a better cosmetic effect than small ones.
3. No old scar should be spared between transplanted and healthy skin.
4. The replacement should cover esthetic units. For instance, if a scar almost reaches the nasolabial fold, the transplant should extend to the nasolabial fold.
5. In extensive reconstruction of the chin, the flap should extend to the vermillion border, even if healthy skin has to be sacrificed. Small islands of healthy skin in this region only spoil the esthetic effect and do not help functionally.
6. With scars extending to both sides of the face, the replacement should be symmetrical even if healthy skin has to be removed.

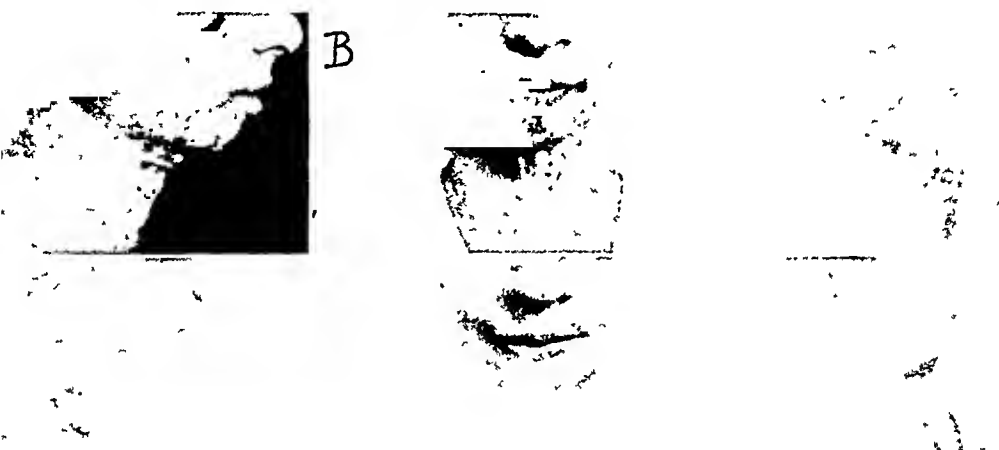


Fig. 3 A-F.—A, B, and C, Preoperative photographs of patient burned by fire. Hypertrophic scars were treated with x-ray. Several years later x-ray atrophy and persisting ulceration appeared on the chin. There had been previous operations with skin graft. D, E, and F, Postoperative photographs after reconstruction of chin and neck with acromipectoral skin tube.

7. To cover the entire chin and cheeks from ear to ear with one piece of skin is difficult. The scar of division should be carefully planned in an esthetically inconspicuous place (Fig. 4, E).

8. The suturing of the flap to the bordering skin should be meticulous in order to leave fine scars.

9. The flap should be tacked down with catgut sutures to the under-surface, to prevent dislocation and hematoma formation.

10. The flap can be thinned and modeled step by step after the transfer has been completed.

11. At the angles of the mouth, small portions of healthy skin should be spared for better function.

Where well-padded, large surfaces of skin are necessary and the best possible cosmetic effect is essential, the tubed flap offers better results than free grafts. However, working with tubed flaps has its disadvantages, too.

The greatest drawback is the time element and the repeated operations involved in its transfer. The minimum number necessary for the transfer of a medium-sized skin tube, about three by eight inches, from the donor area to the defect is three stages: (1) forming the tube; (2) moving one end to the defect; and (3) spreading the skin over the defect. The shortest time interval between each operation is three weeks. This means that for the transfer of a medium-sized skin tube, at least two months are necessary.

If the skin tube has to be advanced from a greater distance by caterpillar movements, or via an intermediary host, one or two more operative steps are necessary with adequate time intervals.

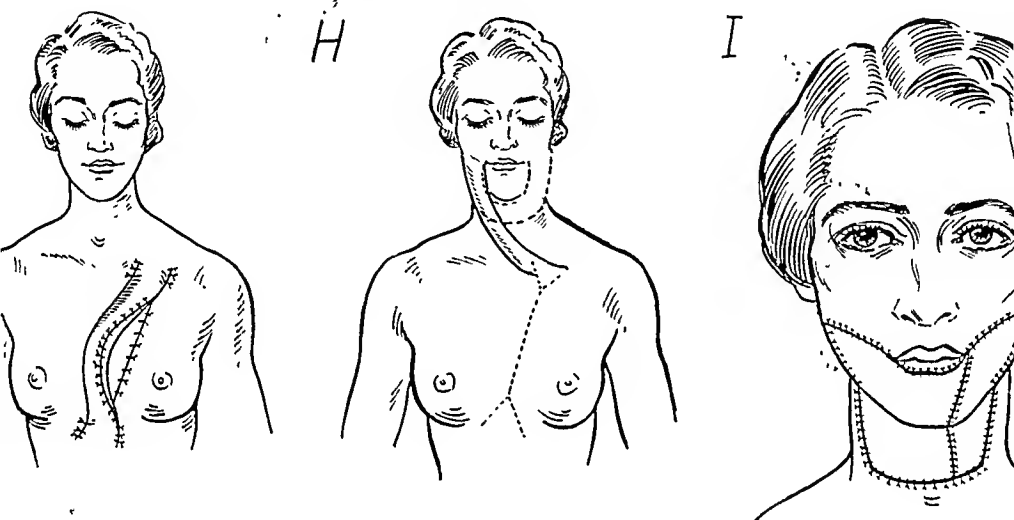


Fig. 3 G, H, and I.—Diagrams of reconstruction with acromipectoral skin tube.

With large skin tubes, naturally more time must be allowed between stages. In Case 4, where six by eighteen inches of skin, that is, over 100 square inches, was transferred from the abdomen to the face, it required seven operations to complete the transplantation and took about seven and one-half months. Naturally, the patient did not have to be hospitalized during the entire time. Only one or two weeks hospital stay with each operation was sufficient.

With the application of free skin grafts instead of tubed pedicle flaps on contractures of the chin and neck, the time of reconstruction can be reduced considerably. Instead of from four to six months which are required for tubed pedicles, only two or three weeks are needed for free grafts.

Skin graft for the treatment of contractures of the chin and neck has been advocated by different surgeons. With the improvement in technique and safe healing, more and more are following this method.

A great impetus in the use of skin grafts has been the ingenious invention of Earl Padgett of Kansas City, the Dermatome. With this mechanical device, large skin sheets of predetermined, calibrated thickness can be cut with relative ease. This invention radically changes the indication and application of skin grafts.



Fig. 4 A-F.—A, B, and C, Preoperative photographs of patient with burn scar contracture of chin, cheeks, and neck caused by fire of clothing. D, E, and F. Postoperative photographs after reconstruction with abdominal skin tube.

The tremendous time saving with grafts versus tubed flaps is not the only advantage. One cannot overlook the surgical risk and discomfort involved in five or six operations. Beside this, the patient is handicapped physically during all these operations and treatments. Finally, the economic aspect, due to prolonged disability and frequent hospitalization, is one of the most important factors which may decide against tubed flaps.

In spite of these disadvantages, we cannot afford to abandon work with tubed flaps. In cases where the best possible esthetic result is important, and the elements of economy and time are secondary, tubed flaps are still superior. They are safer in regard to "full take." With careful observation of the previously mentioned technical points, large surfaces of skin can be transplanted with relative safety. On the other hand, with skin grafts there is more of a risk of partial necrosis.

The well-padded flap does not shrink after healing. On the other hand, the skin graft, whether thick or thin, always shrinks due to the

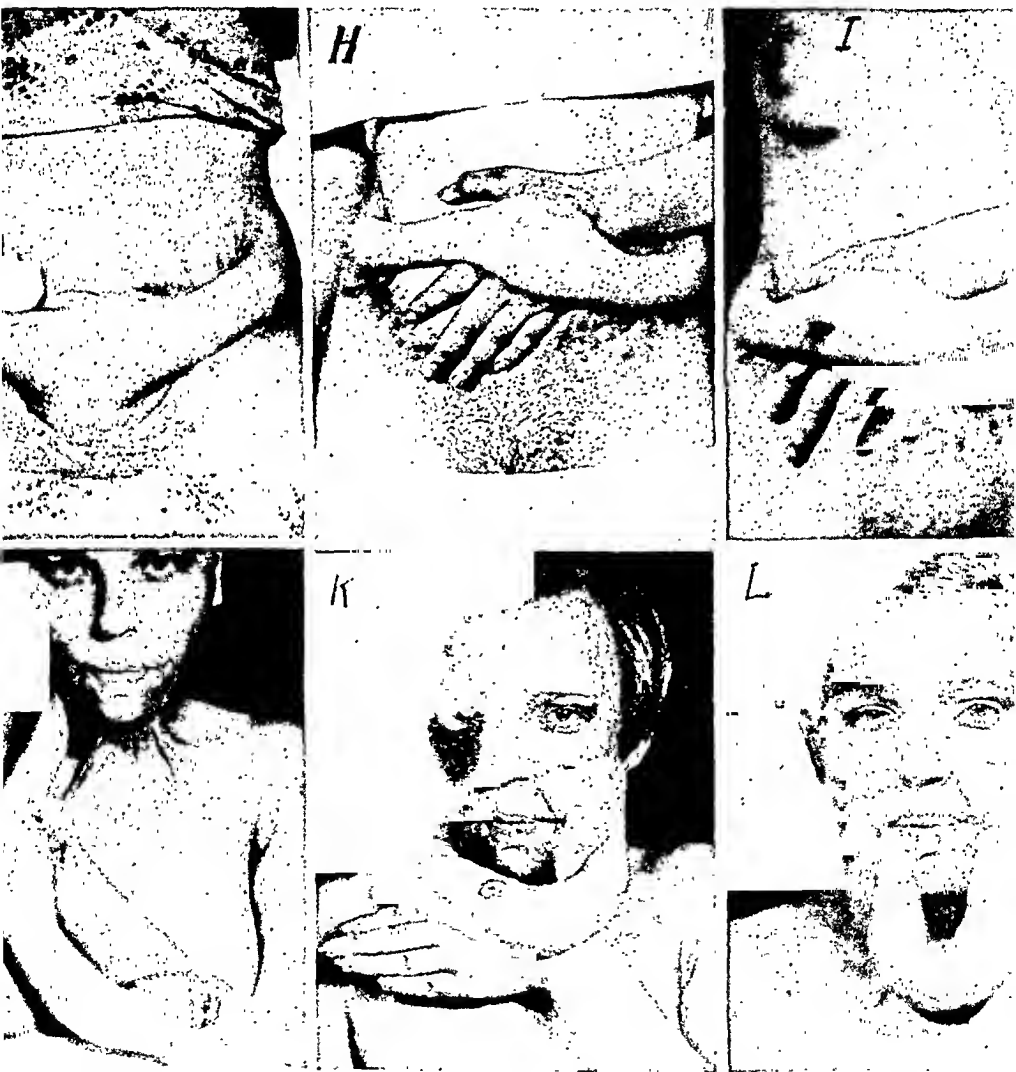


Fig. 4 G-L.—G, Abdominal skin tube, six by eighteen inches long; central portion still attached. H, Central portion of abdominal skin tube attached to back of hand. I, Left end of skin tube attached to forearm. Dark spot in center of tube is superficial burn caused by hot necrocol when moulage was prepared. J, Skin tube transferred via hand to face. K, Both ends of skin tube attached to face. Central portion still attached to hand. L, Skin tube entirely free of intermediary host and nourished by facial attachment. Subsequent operation, skin tube cut and spread over defect. Notice vertical scar on left side of chin in E where flaps were joined.

scar layer being in direct contact with the corium. Naturally, thicker grafts will better withstand this shrinking effect than the Thiersch graft. In extreme cases, the shrinking of the connective tissue layer manifests itself on the surface in waviness and folds.

If a supporting frame, bone, or cartilage has to be reconstructed under transplanted skin, it is unquestionably easier to do it under thick, fat-padded flaps than under skin grafts, if that is possible at all. Furthermore, the flaps are more suitable for surgical modeling, revisions, and shifting.

✓ All these points brought out in comparing the skin grafts with the pedunculated flaps prove that both methods have their advantages and disadvantages. We cannot discard either of the methods or put one ahead of the other with a sweeping general statement. The best service can be given to the patient if the advantages and disadvantages are carefully weighed in each case and the choice of method made accordingly.

## THE VASCULAR PREREQUISITES OF SUCCESSFUL SKIN GRAFTING

### A NEW METHOD FOR THE IMMEDIATE DETERMINATION OF THE ADEQUACY OF CIRCULATION IN ULCERS, SKIN GRAFTS, AND FLAPS\*

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Avenue Hospitals and Metropolitan Hospital Research Unit)

VASCULARITY of tissues is of prime importance in wound healing and repair of tissue damage. Avascular tissues depend on lymph spaces for interchange of nutritive and waste materials. Such tissue may possibly survive but it is not capable of repair and reconstruction. Infection is much more apt to occur in tissue with insufficient vascularity and an infection, once present, can only be overcome by the organism if the reparative mechanism is fully intact, that is providing there is a full rapidly circulating blood supply present.

All types of plastic surgery are, therefore, profoundly dependent upon the presence of an intact vascular apparatus in the field of operation. The recent trend to graft large wounds early, and to depend more on good vascularity than on absolute sterility takes these facts into consideration.

The question as to whether a large wound is well supplied with blood is often hard to decide. Again the extremes are easy to deal with. The freshly granulating pink surface of a clean surgical wound can generally be depended upon to have full vascularization. The gray dirty-looking surface of an old infected ulcer will easily be recognized as having insufficient capillarization. However, the more one carries out the test to be described, the more one will be astonished to see how often, even in a fresh looking ulcer, there are large islands of poor vascularity, and that these islands must not necessarily show a color deviating from the surrounding tissue. Since a successful take in skin grafting depends largely upon the adequacy of circulation in the wound on which the graft is to be put, the immediate recognition of the vascularity must be considered highly important.

In pedunculated flaps it is important to be able to decide at once whether the flap which is created by the surgeon is fully supplied with blood through its pedicle, so that it can survive until its successful connection to the vascular apparatus of the wound on which it is being grafted. Before the separation of the flap from its pedicle one must be

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\*Aided by a grant from the John and Mary R. Markle Foundation.



sure, especially in tubular flaps, that the vascular connection between the graft and its bed has been established in order to avoid sloughing.

Some time ago Lange and Boyd<sup>1</sup> were able to show that fluorescein when injected in a 5 per cent alkaline solution intravenously, travels with the blood stream, reaches the capillaries, and diffuses into the tissue wherever the blood stream reaches an area. This test, which we first devised for the immediate diagnosis of viability of gut in cases of strangulated hernia,<sup>1, 2</sup> can also be used in plastic surgery. The fluorescein can be seen directly in the capillaries and the tissue cells when observed under long wave ultraviolet light. It is, therefore, obvious that this method may be able to aid in establishing the adequacy of circulation in areas where skin grafting is contemplated and also in flaps before and after the grafting.

#### METHOD

In a moderately, or better, fully darkened room the beam of a special small portable and inexpensive mercury vapor lamp\* is directed by an assistant on the area under observation. This lamp carries on its surface a glass filter which excludes all of the harmful ultraviolet and most of the visible light. It transmits light mainly in the region of 3,600 angstrom units. The ulcer or the skin flap will thus appear dark purple or slightly bluish green. For the purpose of later comparison it is advantageous to compare this color with that of the skin of one of the assistants under this light. The patient now receives an intravenous injection of 10 c.c. of a 5 per cent fluorescein solution to which 5 per cent sodium bicarbonate has been added to make it soluble.† This dye is entirely nontoxic and is rapidly excreted into the urine. Within fifteen to twenty seconds, depending on the circulation time of the patient, the ulcer or the skin flap will acquire an intense golden green color in all districts which are reached by the rapid circulation. With the lapse of time the color becomes more intense since more of the dye diffuses from the capillaries into the tissue spaces. Only the living tissue is stained as we showed in other experiments. A clear contrast is created between the parts of the skin and the ulcer supplied with blood (they appear golden green) and the tissue not supplied (purple-blue). Since the light penetrates only 2 to 3 mm. into the tissue, the test gives an indication of the superficial blood supply and further scraping may reveal good vascularization in the depth as indicated by good fluorescence.<sup>3</sup>

#### EXPERIMENTAL EVIDENCE

Pedunculated flaps on the abdomen were formed in four rabbits. The area was clipped and depilated and, under nembutal anesthesia, the animals were operated upon under sterile conditions. In two animals the pedicle was purposely made very small as compared to the large

\*Supplied by the G. W. Gates Co., Franklin Square, Long Island, N. Y.

†Supplied by the C. F. Kirk Company, New York.

flap. Then 0.4 c.c. of the fluorescein solution was injected into the ear vein and the area of the flap which showed fluorescence was outlined with a skin pencil. The flap was replaced on its previous bed and the course of the healing observed. Both animals showed necrosis of the skin flap within forty-eight hours after operation, exactly at the line of demarcation as previously indicated by the fluorescein.

In two animals the skin flap was formed according to the usual procedure, that is, the pedicle was not essentially smaller than the flap. Otherwise the procedure was the same as in the other animals. The fluorescein test indicated full fluorescence throughout except for the tip of one of the flaps which was cut off. Both animals showed a normal take of the flap without any gangrene.

Three rabbits were subjected to the same procedure and a pedunculated flap formed with the pedicle nearly the same width as the flap. In these animals the pedicle was prevented from taking, however, by putting a piece of rubber dam between it and the underlying tissue. The flap itself was sutured on its old bed after the fluorescein test had indicated full blood supply through the pedicle. Every forty-eight hours the animals were subjected to a fluorescein test with a tourniquet around the pedicle. Two animals showed the first traces of fluorescence in the flap after 144 hours when the blood supply from the pedicle was clamped off, while the third animal showed fluorescence after 192 hours. All pedicle transplants took completely. After eight, ten, and twelve days, respectively, full fluorescence of the entire flap was present with the pedicle clamped off, indicating full connection of the vascular systems of the flap and the base. It was interesting to note that the vascular connection always started at the edge and slowly progressed in irregular patterns toward the middle.

Davis grafts were removed from the flanks of two rabbits and from the hind legs of two others. They were transplanted on a fresh wound on the opposite side of the body. Some fluorescence indicating direct vascular connection was first discovered with great regularity after 96 hours and full fluorescence of the entire pinch graft was present in most of the grafts after 144 hours.

In this connection it should be mentioned, however, that in all animals the bed on which the flap or the Davis graft was implanted was fully vascularized and represented a fresh wound. All wounds showed excellent fluorescence throughout.

#### CLINICAL EVIDENCE

Since these examinations were started in the course of our observations of the effectiveness of the fluorescein test in peripheral vascular diseases and were not primarily intended as a surgical procedure, our clinical material is small as to actual skin grafting.

Seventy-six cases of leg ulcers were observed, and the value of the fluorescein test for their prognosis was tested. All patients received

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\*Supplied by the G. W. Gates Co., Franklin Square, Long Island, N. Y.

†Supplied by the C. F. Kirk Company, New York.

gard to their appearance in daylight often gives a misleading impression of their vascular status.

8. Davis grafts in human beings also show the first signs of direct capillary connection after ninety-six hours.

9. Tubular grafts in human beings can easily be tested with the fluorescein method to determine the time when they can be separated from their pedicle without danger of sloughing.

I wish to thank Dr. Louis R. Kaufmann and Dr. John O. Herrlin for letting me examine several cases from their service.

#### REFERENCES

1. Lange, K., and Boyd, L. J.: The Use of Fluorescein to Determine the Adequacy of the Circulation, *M. Clin. North America* 26: 943, 1942.
2. Herrlin, J. O., Glasser, S. T., and Lange, K.: New Methods for Determining the Viability of Bowel, *Arch. Surg.* 45: 785, 1942.
3. Lange, K., and Boyd, L. J.: The Technique of the Fluorescein Test, *Bull. New York M. Coll., Flower and Fifth Ave. Hosps.* 6: 78, 1943.

The second group of cases consisted of seventy-seven grafting procedures in connection with the treatment of burns in sixteen different patients. In only four instances did we have an opportunity to carry out grafting procedures earlier than one month after the burn was sustained. The remainder of the patients had had chronic granulating wounds for periods ranging up to seventeen months prior to admission. Many of the patients were markedly debilitated and the granulation tissue was often badly scarred and of very poor quality. The granulating areas ranged in size from one-tenth to one-half of the total surface area in the different patients. In seven of the sixteen cases, 30 per cent or more of the skin surface was involved.

In sixty-six of the grafting procedures carried out in the burn cases, the grafts were of the split-thickness type. Occasional sheet grafts up to 32 square inches in area were used, but for the most part the grafts were cut into "postage stamp" pieces. The fibrin fixation technique used was of great immediate mechanical aid in holding the grafts in place during the operation and during the application of the dressings. As in the case of the primary grafts, the hemostatic action of the thrombin used as the clotting agent for the plasma proved valuable in preventing hemorrhage from the granulation tissue. This was particularly true in some of the cases in which it seemed advisable to cut away portions of the exuberant granulation tissue at the time of the grafting operation. The grafts were usually protected by a plain gauze screen or wax mesh gauze screen. The ability of the fibrin clot to hold the grafts firmly in place was quite gratifying in most of the cases. In fact, in a number of the cases the grafts were left entirely open and merely protected from trauma by a wire cradle. In these, the fibrin proved adequate for mechanical support of the grafts in cooperative patients. In several of the cases grafts placed in dependent positions have been held successfully with no support other than the fibrin clot. The artificially supplied fibrin clot has also proved very useful to fix the gauze screen to the wound. To accomplish this, we flood the screen with a small amount of plasma and thrombin after it is placed in the desired position over the wound. In cases treated in this way no celloidin or other material has been needed to hold the screen firmly in place. Subsequent autolysis of the fibrin clot with loosening of the grafts, or of the screen, has not been a troublesome feature except in a few of the more severely infected wounds. This was equally true of the cases in which treatment of the wounds with wet dressings was resumed within two to four hours after the operation. This, we feel, is very valuable in that it permits resumption of aggressive treatment of extensive infections early in the postoperative period. Also, the stability of the grafts permits greater activity on the part of the patient during this period.

The usual difficulties in evaluating the efficacy of clinical therapy in terms of final results were, of course, encountered. In the group here reported, the over-all percentage of successful takes was 78 per cent.

This is somewhat better than we have had in the past with cases of this type. Other factors, however, as more careful attention to dietary and general treatment, segregation and special nursing service, frequent saline baths, and the local use of the sulfonamide drugs, no doubt have contributed much to the improved results. For this reason, it is difficult to evaluate the influence of any single factor. There can be no doubt, however, but that the fibrin fixation has been at least of considerable mechanical aid. Conclusive data showing a stimulating effect on the healing process are not available, but this has been suggested by surprisingly good results in some of the more unfavorable cases.

In the remaining eleven grafting procedures in burn cases, the grafts were of the "pinch" type. In these, again, the use of thrombin and plasma for fixation of the grafts in a fibrin clot was of definite mechanical aid and the results suggested that the presence of the artificially supplied fibrin increased the likelihood of the grafts remaining viable. The percentage of successful takes in this group (73 per cent of all grafts survived) was not quite as good as in the case of the split-thickness grafts, but in general the pinch type grafts were elected in the less favorable cases.

There were thirty-five grafting procedures in cases which fell into the category of chronically infected wounds, other than burns. Most of these were cases in which the chronic granulating wounds followed surgical treatment of severe infections. In these, thirteen were of the split-thickness type and twenty-two of the pinch type. The results in these (68 per cent) were slightly less favorable than in the burn cases. The usefulness of the fibrin clot for mechanical support of the graft was more evident perhaps in this group because of the nature of some of the wounds. In several of the cases, deep crater defects required placing numerous small grafts on the sides and bottom of the crater. Many of these would have been very difficult to hold in place by any other means and the fibrin proved adequate to hold the grafts in place until healing occurred.

In this study, we have arbitrarily classified as successful, all transplants which appeared healthy on the tenth to the fourteenth post-operative days. In the case of small transplants, the percentage takes was determined by counting the total number of grafts. In the case of the relatively few large sheet grafts, we have estimated the area of the graft which remained viable. In the entire series, there were about 8 per cent of the grafts in which "late slough" occurred two to four weeks after operation. No grafts were lost in this manner in the cases in the primary graft category. The percentage of the grafts eventually lost in this way was about equal in the cases falling into the other two categories and is about the same as we have had in the past in cases of this type. Our evidence, to date, does not indicate that the presence of the artificially supplied fibrin either increases or protects against this complication.

We have not yet had the opportunity to study the possible usefulness of the fibrin fixation technique in other types of operations. A few preliminary studies have been made in dogs with fibrin fixation of experimental bone transplants. Autologous plasma was used in these as the source of the fibrinogen and the thrombin described previously was used as the clotting agent. In these preliminary studies, the artificially supplied fibrin has appeared to be particularly helpful in fixation of thin osteoperiosteal grafts. Healing has proceeded very satisfactorily with no suggestion that the thrombin and plasma used had untoward effects.

#### DISCUSSION

The possibility of local irritation of the tissues resulting from the fibrin, or from the foreign protein of the thrombin which is prepared from beef plasma, naturally arises. In our work so far, there has been no suggestion of either local or general untoward reaction attributable to these materials. In several of the patients, we have had occasion to use the fibrin fixation technique repeatedly, at times at intervals of many weeks. In these, there has been no suggestion of the development of hypersensitivity to the foreign protein. In some of the work with nerve suture, it has been suggested<sup>2</sup> that use of autologous plasma resulted in less fibrosis than did heterologous plasma. We have not used heterologous plasma as a source of fibrinogen in any of our cases. The thrombin is highly purified, and, as it is very concentrated regarding activity, only very minute amounts of the protein were needed to effect almost instantaneous clotting. It may well be that heterologous sources of fibrinogen would result in unfavorable reactions, particularly if the preparations were relatively crude.

We have not yet had sufficient experience to determine the optimum amount of fibrin to be used in the wound. In their work with nerve suture, Young and Medawar<sup>1</sup> found that the mechanical fixation of the tissues could be enhanced considerably by increasing the fibrinogen concentration of the plasma several fold. This did not, in their experience, cause undue fibrosis in the healing stage, even though the fibrinogen was of heterologous source. It may be that the use of purified fibrinogen solutions having much greater concentrations than that of native plasma would materially improve the results in certain instances.

In a number of our cases, as well as in studies on the use of thrombin as a hemostatic agent,<sup>7</sup> we have had occasion to use thrombin in wounds along with large amounts of the bacteriostatic drugs of the sulfonamide group. In these, there has been no suggestion that the drugs interfered with the activity of the thrombin or vice versa.

#### SUMMARY

By use of plasma and purified thrombin, fibrin fixation of tissue in operative procedures can be accomplished readily. In our experience, artificially supplied fibrin clots, obtained in this manner, have proved

# THE TREATMENT OF BURNS AND OTHER EXTENSIVE WOUNDS WITH SPECIAL EMPHASIS ON THE TRANSPARENT JACKET SYSTEM\*

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SINCE the literature on burns is voluminous and fairly up to date, we shall not attempt another very detailed description of the causes, of systemic metabolism, of local pathology, or even of the many methods of treatment. The purpose of this article will rather be to give a résumé, in more or less synoptic form, of those facts concerning the patient as a whole and his wounded tissues which we consider absolutely essential to rational management. We apologize for omitting details of certain methods of treatment which have proved valuable, but concerning which, on account of lack of space, only briefest mention can be made. The details of most of these methods will be found in a previous article.<sup>1</sup> Because of recent developments the transparent jacket or Theras system of treating burns will be described in full detail.

We shall deal principally with lesions resulting from accidental a- cation of heat through a dry or moist medium to the surface of the l although the term "burn" is loosely applied to ex- exposure c skin to chemicals, electricity, friction, light, and rays.

For the most part our discussion will be con- tensive b although the treatment for a small damaged are " will b- same as that of a larger one. First-aid meas- tioned

*Incidence or Prevalence.*—Large conflagration contributing agency, whether in war or peace. oil on water, bomb blasts, theater and amuseme sale producers of burns, while airplane and au water bottles, percolators, and open grates contri-

## SYSTEMIC REACTION

Almost immediately following extensive cutaneo will suffer from an extreme grade of nervous shock , terized by mental léthargy or unconsciousness and . This is usually attributed to overstimulation of injure and, although promptly treated, may lead to death fric tion.

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\*The investigation of the transparent jacket method has be sistence of a grant from the Committee on Therapeutic Resea macy and Chemistry, American Medical Association from 1936



to be of distinct mechanical aid in skin-grafting operations. The results in many of the cases have suggested that the fibrin also promotes healing but additional data are needed for definite conclusions on this point.

Thrombin in sterile and highly purified form is now available for clinical trial. The technique of fibrin fixation is simple to carry out and might be used to control the amount and site of deposition of fibrin in various types of operative procedures. Many possible applications immediately suggest themselves.

There have been no untoward results from the use of thrombin and plasma for fibrin fixation in the 122 operations in which we have used this technique.

The human plasma used in this work was obtained from the hospital blood bank through the cooperation of Doctor E. L. DeGowin. In more than one-half of the cases the operative work was done by one of us (R.T.T.). For the remainder of the cases, we are indebted to other members of the Department of General Surgery.

#### REFERENCES

1. Young, J. Z., and Medawar, P. B.: Fibrin Suture of Peripheral Nerves: Measurement of The Rate of Regeneration, *Lancet* 2: 126-128, 1940.
2. Tarlov, I. M., and Benjamin, B.: Autologous Plasma Clot Suture of Nerves, *Science* 95: 258, 1942.
3. Tarlov, I. M., and Benjamin, B.: Plasma Clot and Silk Suture of Nerves. I. An Experimental Study of Comparative Tissue Reaction, *Surg., Gynec. & Obst.* 76: 366-374, 1943.
4. Seegers, W. H., Brinkhous, K. M., Smith, H. P., and Warner, E. D.: The Purification of Thrombin, *J. Biol. Chem.* 126: 91-95, 1938.
5. Seegers, W. H.: Purification of Prothrombin and Thrombin: Chemical Properties of Purified Preparations, *J. Biol. Chem.* 136: 103-111, 1940.
6. Seegers, W. H., and McGinty, D. A.: Further Purifications of Thrombin: Probable Purity of Products, *J. Biol. Chem.* 146: 511-518, 1942.
7. Tidrick, R. T., Seegers, W. H., and Warner, E. D.: Clinical Experience With Thrombin as an Hemostatic Agent. *SURGERY* 14: 191-196, 1943.
8. Padgett, E. C.: *Skin Grafting From a Personal and Experimental Viewpoint*, Springfield, Baltimore, 1942, Charles C Thomas, Publisher.



“There is a substance produced in burned tissues (in larger quantities in extensive skin burns than in those of other tissues) which circulates in the blood, either in, or closely adsorbed to the red blood cells and which causes the symptoms of toxic shock and, in some cases, death. The toxin is produced in increasing amounts following the burning of the tissues until twenty-four to thirty-six hours after injury. It is produced only as a result of burning living tissues. The toxin is most highly concentrated in solutions of corpuseles suitably treated and least in the blood plasma.

The autopsy findings of Bardeen and Weiskotten, which are quoted later under Pathology, are highly indicative that the action on organs is, according to the latter, that “of a more or less specific poison.” Certainly such lesions could not be ascribed alone or primarily due to hemoconcentration.

The controlled work which I have carried out on the prevention of absorption from extensive superficial burns with absence of symptoms in guinea pigs, dogs, and human beings<sup>12, 13, 14</sup> by local use of vasoconstrictor drugs, notably adrenalin chloride, has convinced me that Robertson and Boyd’s conclusions concerning a burn toxin are sound. The effect of the epinephrine in preventing local loss of plasma into the tissues and from the surface can only account partially for the absence of symptoms, while prevention of absorption of toxic products from the surface must also be taken into account. Most of the work performed on injection of extracts from burned tissues, as well as symbiotic experiments in which one dog is burned, while appearing conclusive, has lacked proper controls.

The recent experiments of Christophe<sup>15</sup> (quoted by Harkins) appear conclusive in showing that there is a burn toxin no matter if its nature is unknown and that it is fixed early in brain tissue. In these, to quote Harkins, “If the blood of a normal dog was allowed to perfuse through the amputated leg of another dog which leg is then burned, the normal dog dies.” Further quoting Harkins, “In a second experiment, Dog A (whose hind legs are burned) is connected by means of the central ends of its carotid artery and jugular veins to the distal ends of the carotid and jugular to Dog B (whose other carotid and jugular are ligated and whose vertebral vessels were ligated at a previous operation). If the perfusion is carried out long enough Dog B dies with all the signs of a burn death. To show that the supposed toxin affects only the brain of Dog B, Dog B’s blood was perfused through a third Dog C which did not die.”

Harkins concludes significantly that the possibility of a toxin that acts on the brain early in the course of a burn is strongly suggested and that early fixation of such a toxin in the brain might explain the difficulty of its isolation elsewhere.

These experiments are in agreement with our dictum that “burns should be regarded as surgical emergencies of the first order,” and may

well explain why various pressor drugs applied early after a burn, almost entirely abolish toxic symptoms.

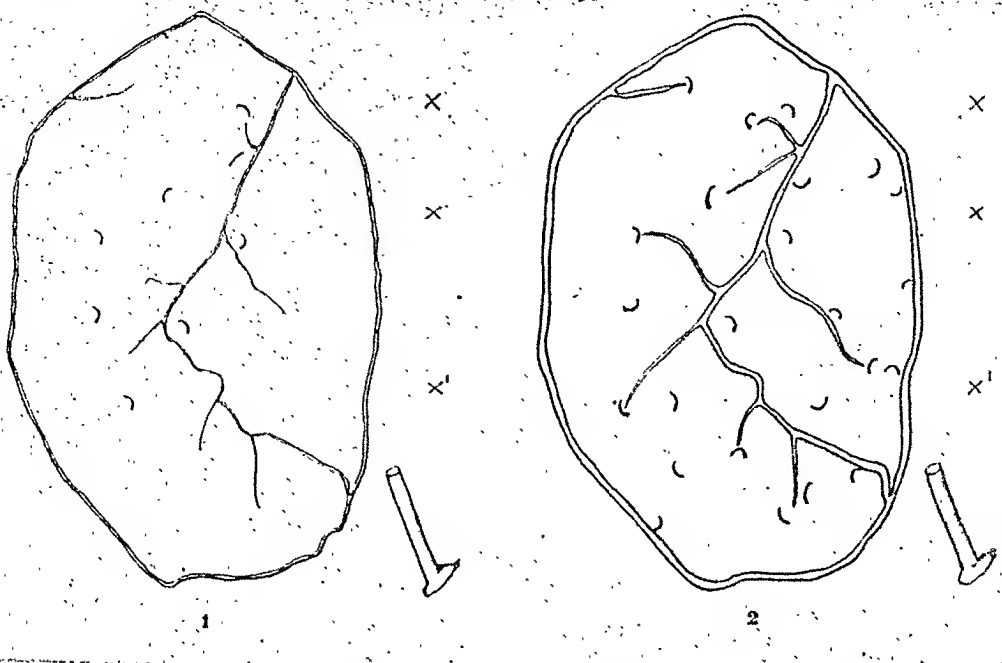
Regarding the theory that bacterial toxins produce all or a large share of toxic symptoms in burns in the secondary stage, there is no doubt left after the work of Aldrich (1933),<sup>16</sup> Firor,<sup>17</sup> Cruickshank,<sup>18</sup> Wilson and co-workers (1938)<sup>19</sup> and many others, that in one to six days the average severely burned patient will suffer from hemolytic streptococcal infection, on the surface or even in the form of bacteremia or scarlet fever. We do not feel, however, that this fact at all precludes the probability of a toxin or toxins from the damaged tissues continuing to absorb into the blood stream and simultaneously causing additional damage.

From a great many experiments applying epinephrine on blood agar in low concentrations to hemolytic streptococcal cultures, as well as to animals, we have found<sup>20, 21</sup> such solutions of this vasoconstrictor drug to be bacteriostatic. In vitro the growth of the cultures was arrested. In guinea pigs, dogs, and human beings infections failed to develop on the damaged surfaces.\* Identical results were obtained when adrenalin chloride, free from the chloretone usually present as a preservative, was employed.

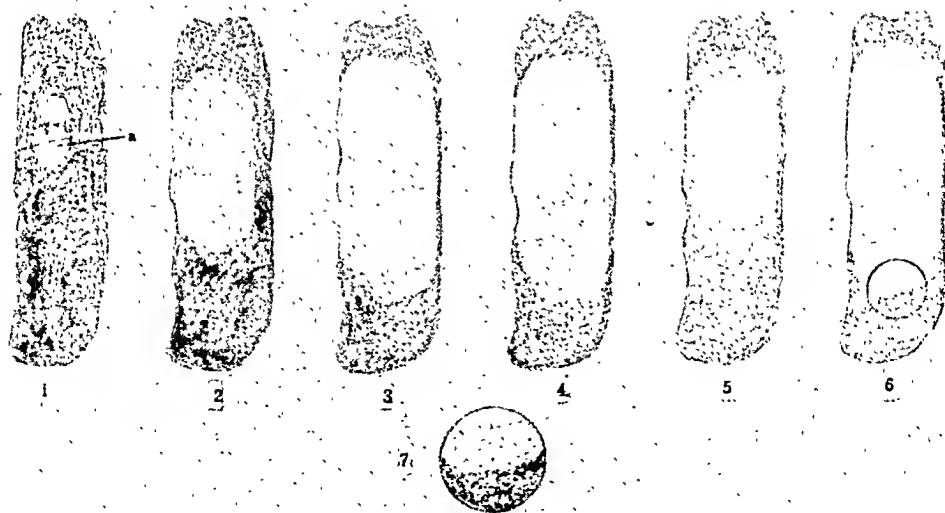
No matter whether one favors the theory of a toxin from the burned tissues or from bacteria implanted on the latter, he cannot doubt one fact—that from one of these factors or both an increase in capillary permeability is produced either directly or secondarily and that increased absorption and transudation result. I have shown<sup>21</sup> (see Fig. 1) that the burn of a hot needle (shaft) touching the skin at the human nail bed produces an opening or dilatation approximately three times the capillary loops normally seen under the binocular microscope with an increase in local color evident. Since the needle touches too small an area for heat to be delivered to more than two or three capillary loops, and since the dilatation is progressive, we conclude that some soluble toxin from the tissue injured by the needle is diffused locally through the capillaries to cause it (Fig. 1). Further, epinephrine applied to the nail base reddened from the dilatation of the capillaries will restore the circulation to an approximately normal condition and prevent blistering. (See Fig. 1.) On large very red surfaces from which the epidermis has come off as the result of blister formation, we have repeatedly been able to dip an applicator in epinephrine and paint a letter of the alphabet and, because of the vasoconstrictor effect, have it appear distinctly blanched against the reddened background of the burned surface.

Krogh<sup>22</sup> and others have shown that dilatation of the capillaries beyond a certain point causes pouring out of plasma into the tissues between the endothelial cells which are too far apart to act any longer as an osmotic membrane.

\*These experiments were carried out with the assistance of Mr. Mikesell and Dr. Wherry of the Department of Bacteriology of the University of Cincinnati.



A.



B.

Fig. 1.—A, Effect of burn with needle at X-X,<sup>1</sup> in dilating capillaries, venules, and arterioles. 1, Shows a few loops open at time of burn. 2, Shows the tremendous increase in number and size of visible vessels three minutes after the burn. (Observations made through oil with binocular microscope on human nail-bed. B, Retrogression of congestion in vessels in human burn on back of hand under pressor action of adrenalin chloride. 1, Fluid expressed from blister at a and adrenalin chloride 1:1000 injected into blister with needle. 2, Shows pallor in zone surrounding blister after one minute. 3, Pallor four minutes later. 4, Pallor 10 minutes later. In 5 vasoconstriction is beginning to relax after three minutes more, after which time epinephrine was again injected into blister. 6, Pallor is again very extensive after thirty-two minutes. 7, Shows area in circle magnified.

Most superficial burns producing reddening and blistering evidently cause various degrees of damage to, but not destruction of, the capillaries. The latter may dilate and pour out plasma into the tissues but later may recover their osmotic function as resolution occurs.

An article by Davidson and Matthew<sup>23</sup> is in line with these views. After showing that the toxemia of burns offers a particularly good opportunity for studying capillary permeability following their studies they state that, "In extensive burns there is first an increased permeability of the capillaries which explains the characteristic concentration of the blood."

Menkin<sup>24</sup> feels that an intermediate substance in burns causes the increase in capillary permeability rather than damage to the vessels by the heat.

Since the introduction by Davidson of tannic acid, evidence has accumulated to show that the moistening of the tanned eschar or membrane aggravates toxic symptoms. This is thought by many to be due to the solution dissolving toxic products in the membrane which absorb with the solution. Others, including Aldrich,<sup>25</sup> contend that the aggravating symptoms which follow moistening might be explained on an infective basis as well.

Two articles by Menkin<sup>26, 27</sup> seem to us to be most significant since they show that the edema fluid of experimentally burned tissues contains a substance which promotes capillary exudation emigration of leucocytes and dilatation. This substance, or the active factor, Menkin showed to be a dialyzable protein-free, crystalline, doubly refractive nitrogenous substance, not a protein, yet containing amino and carboxyl groups. Various types of inflammatory exudates, as stated by Harkins, were obtained by Menkin, either by the introduction into normal tissues of a chemical irritant, or by a burn or bacteria and all were found to contain this substance. He states his belief that it is "an intermediary breakdown product of protein metabolism probably belonging to the group of relatively simple polypeptides."

This seems to be as satisfactory an analysis as has been offered of the chemical nature of the injurious substance in burns. The fact that other forms of trauma may produce this substance seems in no way to lessen its significance in burns.

In temporarily closing this part of our discussion, considering the evidence presented on the question of toxemia we feel that a few conclusions are warranted as follows.

There is a toxin produced in increasing amounts following the burning of the tissues up to twenty-four or thirty-six hours. Its composition is split protein in nature, probably a polypeptide. Its origin, while not certain, is in all likelihood to be found in the breaking down of proteins by the heat. While the manner in which it exerts its harmful effects is not completely worked out, it is evidently absorbed by the red blood cells

and probably carried early to the brain to become fixed in the brain tissue. Damaged tissue must probably be in contact with living tissue before the toxin can be formed, as evidenced by the appearance of toxic symptoms twenty-four hours after the injury. The pathologic changes constantly found in the central nervous system, heart, liver, and other organs in fatal cases are too great to be explained by local fluid loss from the burned surface and local edema. A circulatory toxin must be assumed. Wilson and his associates<sup>28</sup> ruled out all causes except acute toxemia as a cause of death in thirteen out of a series of sixty-five severely burned patients and reported that in four others the toxemia was very severe. I feel that they are right in concluding that, "a specific toxin which is formed in burned tissue and absorbed into the blood stream, receives support from this investigation."

Only briefly and with apologies to those who have done detailed and conclusive work on the subject will we review the changes in the blood circulation and physics and chemistry of the blood which we regard as established.

*Changes in Blood Circulation.*—Baraduc,<sup>29</sup> in 1862, stated, "The thromboses so generally found in such cases are due to the thickening of the blood, with slowing of the current in consequence of the withdrawing from the blood of the serum found in blisters." Klebs,<sup>29</sup> in 1877, emphasized the effect of burns on the circulation stating his findings of marked stasis in the large blood vessels and an enormous crowding together of red blood cells. In 1881, Tappeiner<sup>29</sup> carefully studied four fatal burns and concluded that while death was due to many factors, chief among them was loss of blood plasma through transudation. Locke's<sup>29</sup> chief findings in ten severe cases were sluggish flow and dark purplish appearance of the blood, an immediate increase of from 1, to four million red cells, a rapidly increasing leucocytosis to between 30 and 50 thousand white cells, a considerable destruction of leucocytes; the presence of myelocytes in severe cases and a marked increase in the number of platelets. To these cellular changes must be added the findings of Wilson and associates<sup>30</sup> of marked eosinophilic concentration in organs.

I have already reported the outstanding work of Underhill, Kapsinow, and Fisk on my patients at New Haven, and later of Willis, which demonstrated the great increase in blood concentration evidenced by hemoglobin increase. The latter author also showed that hemoconcentration failed to occur after débridement of the burned area.

Blalock,<sup>31</sup> in 1931, made the significant observation that the outpouring of fluid into the tissues (which he and Beard showed to have the same protein content as plasma) plays an important part in the reduction of blood volume and pressure. He showed that the weight of a burned extremity in a dog, over the normal unburned one, would average as much as 3.34 per cent of that of the body after time intervals of

six to twenty-six hours. This he calculates would represent 57 per cent of the total plasma. Such a loss in extensive human burns he feels can contribute greatly to a lethal outcome by producing a high degree of circulatory shock. He concludes, "It is entirely possible that such agencies as tannic acid and epinephrine exert their beneficial effects by preventing the loss of fluids, rather than by stopping the absorption of toxins." However, he never intimated that death was due solely to loss of fluids, but rather stated, "After the blood volume is reduced and the blood is very concentrated, it is likely that toxins if present even in small amounts will exert deleterious effects since elimination by the kidneys is greatly reduced."

Johnson and Blalock<sup>32</sup> found that associated with the loss of fluid into the tissues there was a decrease in cardiac output which, unlike the blood pressure fall, was gradual. According to their findings the blood pressure remained up until near death and then fell rapidly.

Harkins<sup>33</sup> experiments employing a tipping apparatus for dogs showed a definite fluid shift in burns and graphically recorded the shift. These corroborated the findings and showed that in some experiments "more than half the ultimate amount of fluid collected in one hour."

*Changes in Blood Chemistry.*—In addition to the changes just described in the physics of the blood, definite changes occur in blood chemistry.

*Anoxia.*—While usually anoxia has been shown to exist in the severe shock of burns, its importance has seemed to us to have been underestimated. Harkins gives a good summary of the work on anoxemia or anoxia as follows. Krogh,<sup>22</sup> in 1922, recognized the vicious circle in shock and the possible role of anoxia in it. In 1937, Bois and Hartman,<sup>1</sup> working on liver necrosis following burns in dogs, ascribed anoxia associated with shock, plasma loss, and hemoconcentration as principal causes of liver necrosis. Tannenbery, in 1939, found liver changes in simple cases of anoxia. Keeley, Gibson, and Pijoan observed in their experimental burns that the oxygen saturation of venous blood was reduced in all animals. It reached values of less than 10 per cent prior to peripheral collapse in those animals that succumbed. Black, in 1940, advised treatment of burns in patients with high concentrations of oxygen by means of a Boothby-Lovelace-Bulbulian mask.

The logic of this measure is found in the fact that there are plenty of red cells in the blood but that oxygenation of them is needed because of the slowing of the blood current from hemoconcentration.

Regarding the question of diminished blood flow in the shock of severe burns, not much is known, except that in shock in general it is known from the work of Freeman, Shaw, and Snyder<sup>34</sup> that the blood flow through the patient's hand is diminished.

*Epinephrine and Suprarenal Changes.*—Since lesions of both parts of the adrenal gland are so frequently found both in animals and man,



and since epinephrine and cortical hormone are both substances which affect metabolism, it is not surprising to find that the part which the adrenals play in the metabolism of the burned patient has been widely studied.

Weiskotten,<sup>35</sup> Greenwald and Eliasberg,<sup>36</sup> Berkow, Albright and others have noted early pathologic changes in the adrenals. They found glands edematous and the cut surface of both medulla and cortex hemorrhagic. Others have proved a focal exhaustion of lipoids and a necrosis to be present.

Brooks and Blalock,<sup>38</sup> however, present evidence to show that similar changes in the adrenal glands follow trauma to muscle and hemorrhage which lead them to conclude that they are not specific of burns.

In view of these reports, we felt it important to examine the autopsy material from fatally burned patients at Vanderbilt Hospital with reference to adrenal changes. This was done with the collaboration of Dr. Ernest Goodpasture<sup>39</sup> with the following significant findings in seven cases.

In two who died early (six to eleven hours after extensive burns) the adrenal vessels were congested and red cells were within and outside the capsule. Cells in medulla and cortex of one showed cloudy swelling, and an occasional collection of round cells was seen. In the other, cortical cells had indefinite outlines and nuclei appeared in places grouped in eosinophilic cytoplasm. The medullary cells were eosinophilic and vacuolated.

In five who died late (five, eight, nine, thirteen, and twenty days, respectively) after injury, one had a cavernous defect in the medulla and cortex where most of the substance was destroyed. Three had hemorrhages in the substance of cortex and medulla with varying depositions of fibrin and cellular infiltrations; three had areas of focal necrosis of varying number in the medulla and cortex.

These marked findings in both parts of the adrenals make one surmise that the functions of this important gland must be tremendously disturbed after burns and that substitution therapy may be very important from the standpoint of survival alone.

Hartman, Rose, and Smith,<sup>37</sup> in 1926, showed by testing the denervated cat's iris that epinephrine is secreted early in large amounts and that later autopsy revealed that there was depletion of epinephrine and of lipoids in the suprarenals.

From our studies we are forced to agree with Greenwald and Eliasberg,<sup>36</sup> who have shown that early after burns there is marked hyperactivity of the medulla of the adrenals. This leads at first to great release of epinephrine, which in turn leads to a marked hyperglycemia. This effect, they felt, was due to the shock of the burn acting on the sympathetic nervous supply to the glands and results in early death in severe cases.

In cases in which death occurred later than twenty-four hours after the burn, these authors found marked degenerative changes in the

adrenals with concomitant low blood sugar levels. During this stage of adrenal degeneration they claimed that a decreased amount of epinephrine entered the blood stream, thus failing to stimulate the liver in its normal glycogenolytic function. Hence, hypoglycemia was the rule. We have seen this late hypoglycemia with blood sugar reaching 17 in two fatal cases. Convulsions occurred in both and death ensued in one in spite of administration of glucose and insulin.

Before leaving the subject of damage to the adrenals in burns, we think it important to point out the apparent association of adrenal damage and Curling's ulcer. McLaughlin<sup>8</sup> produced partial destruction of the adrenal glands experimentally in twenty-four dogs with resultant duodenal ulcer formation. Harkins collected three cases of Curling's ulcer with adrenal hemorrhages, but of course lesions were present in other organs. The association, while not by any means invariable, is suggestive.

Application of weak epinephrine solution to a burned surface, a method which we introduced, has very little bearing on the chemical changes in the blood. Since epinephrine inhibits its own absorption as well as prevents locally an absorption of toxins, and likewise checks the local pouring out of plasma into the tissues the only resulting change noted in the blood is a slight rise in the blood sugar followed later by a slight fall.

*Adrenal Cortical Hormone.*—There is no particular reason to believe that the cortex suffers any less pathologic change in burns than the medulla. Weiskotten and many others have found severe changes in both. Like the medulla under the early stimulation of a burn it is logical to anyone that it will oversecrete hormone and later during degeneration secretion will diminish or fail. Many authors feel that damage to it causes the shock in burns. Space does not permit a full review of the literature on this point. Suffice it to say that Swingle and his associates<sup>40</sup> after much experimental work, report a pressor action of cortical hormone upon the low blood pressure and feel that it is concerned chiefly with the maintenance of capillary tone and, therefore, has a regulatory control function of the volume capacity of the circulatory system. The work of Wilson and associates<sup>41</sup> in demonstrating clinically the beneficial effects of this hormone has great promise and will be mentioned later.

*Nonprotein Nitrogen and Polypeptide Nitrogen.*—McIver's findings of a nonprotein nitrogen over 45 in fatal and under 37 in nonfatal cases are fairly typical. Apparently histamine substances account for the increase. The French school lay more stress on the increase in polypeptide nitrogen. Wilson and Stewart claim that the nonprotein nitrogen increases following burns in their patients are relatively greater than those of urea nitrogen.

*Plasma Proteins.*—Many writers have reported lowered plasma protein values with loss of more albumin than globulin, thus changing the

albumin-globulin ratio. This is probably due to the loss of plasma at the site of the burn. It would seem to be significant in emphasizing the importance of keeping nutrition in the burned patient at a high level and administering blood plasma. In one of the patients from the Coconut Grove fire, who was treated by Dr. Charles Lund, we understand that a daily diet of 6,500 calories was kept up constantly. Although a very large portion of the patient's body was burned he was doing well at the time last heard from.

*Carbohydrate.*—Sugar metabolism is of great importance in burns.

*Hyperglycemia:* The evidence for a great increase in blood sugar early after some burns is conclusive. Greenwald and Eliasberg; Schreiner, Martin; Hartman, Rose and Smith; Slocum and Lightbody, McIver, Lambret and Driessens all have reported this.<sup>8</sup> I have given the evidence of the former two authors that hyperadrenalinemia is responsible for this early rise but this is by no means proved. In fact, Slocum and Lightbody, and later Rudler<sup>8</sup> question the relationship of the adrenal glands and hyperglycemia. The former authors found blood sugar and lactic acid increased following severe burns in adrenalectomized animals. The latter pointed out that the liver also suffers damage in burns (see Pathology) and that this may be the cause as Rabboni and Cacioppo had previously hypothesized. I am thoroughly in agreement with this viewpoint. Some time ago I treated a man with a gunshot wound of the liver, which I sutured. For two weeks after this he had a very high blood sugar value which could be accounted for in no other way than on the ground of liver damage. Following this, experiments were performed on experimental animals of lacerating and crushing the liver and a similar hyperglycemia occurred which could not be accounted for by anesthesia.

*Hypoglycemia:* The phenomenon of extremely low blood sugar values in our experience and that of many others occurs late in burns (forty-eight hours to six days) and is an ominous sign. It is usually accompanied by generalized convulsions and death. We have already reported two fatal cases in children (see Suprarenals) with terminal blood sugar values 17 or below. Greenwald and Eliasberg have reported two, and Trusler, Egbert, and Williams, others. In one of our fatal cases the patient was given glucose and insulin intravenously with temporary benefit.

*Plasma (or Serum), Sodium, and Potassium.*—Evidence at hand indicates that potassium in the blood plasma usually rises after burns, but inconstantly so, only following shock, and then rarely to high levels. Shock in burns cannot be ascribed to this rise.

On the other hand *serum sodium* values have been found almost universally to be low following burns. The mechanism of this decrease reported by many has had a great deal of light thrown upon it, first by Underhill and co-workers,<sup>52</sup> later by Bigger<sup>1</sup> and by Lowdon and associates.<sup>1</sup>

The former showed that the sodium chloride content of the blood is greatly reduced during the stage of hemoconcentration. They felt that in the rapid interchange of fluids during the inflammatory stage of burns, sodium chloride functions prominently. Davidson<sup>1</sup> found low sodium chloride values in the serum of twenty-four burned patients. These values persisted until the sloughs separated and then rose to normal with a corresponding increase in urinary chlorides. This chloride crisis is similar to that of pneumonia.

Bigger stressed the significance of high blood concentration and low blood volume and reported good results in restoring the blood volume in one patient critically burned by using hypertonic sodium chloride solution intravenously. Lowdon and his associates scalded animals fatally and showed that the serum chlorides rapidly decreased before death while the sodium of the red cells tended to increase. These changes occurred regardless of previous section of the spinal cord, and removal of the brain, kidneys, or suprarenal glands. Control experiments in which only scalding was performed showed no such reduction.

By suitable experiments they showed that the sodium was being lost into the scalded tissues.

On patients, two authors, Stewart and Wilson, found that the serum sodium is rapidly restored to a normal level by administration of desoxycorticosterone acetate.

#### LOCAL TISSUE CHANGES AND PATHOLOGY

The older classification of burns in six degrees or in three (namely, reddening, blistering, and deeper damage) are useless in the light of clinical studies and should be discarded in favor of Goldblatt's two simple types based on end results produced by the lesion:

*Type 1 or scarring burn*, which will require special treatment to minimize scar.

*Type 2 or nonscarring burn*, which will not require special treatment.

In Type 1 or scar-forming burn, no skin structures escape destruction. In Type 2 (first and second degree, old classification) burns there is a variation pathologically from a simple hyperemia to a more severe inflammation and congestion with rapid blister formation. The stratum germinativum is markedly swollen and covered with a layer of leucocytes. If infection does not occur there is a retrogression of inflammatory signs and return to normal in from ten days to three weeks.

From all of the evidence thus far presented, it seems certain that the action of heat on the peripheral blood vessels or of a toxin from burned tissues, or both, causes the peripheral vessels to dilate and their walls to become more permeable causing local pouring out of plasma and absorption of toxin.

It is also clear that epinephrine locally applied may constrict these damaged vessels for forty-eight hours or more at a time, thus preventing

these noxious changes. Our work shows that after seventy-two hours, if epinephrine is gradually diminished in concentration up to 1:24,000, capillary hemorrhages will not occur following its cessation.

#### TREATMENT

We have endeavored to describe fully the essential changes in the patient's metabolism and locally in his tissues as far as these may aid us in an understanding of the rationale of therapy.

While they are artificial and overlapping, we like to recognize three stages in the course of every patient with extensive burns. This will guide us in properly applying methods of therapy.

The *first stage* or that of *primary shock* usually begins immediately and lasts, in patients who recover, from six to twenty-four hours.

The *second stage* or that of *toxemia* lasts from twenty-four hours to twelve days. During this period the patient usually becomes febrile and blood concentration will develop unless combated. Infection may supervene in this stage and the toxemia of the infection may be added to the already existent toxemia.

Curling's ulcer of the duodenum may occur during this period or later.

*Acute Toxemia Causing Collapse.*—During the stage of toxemia, regardless of the size of the burn, severe toxemia leading to collapse and death may supervene at any time from five hours on. It may start suddenly or insidiously. It occurs in a small percentage of cases, but more often in children than adults and more in burns of the anterior portion of the trunk and face than those of the posterior surfaces. Nervousness marked by restlessness, vomiting, hiccup, and convulsions is manifest. The blood pressure may remain normal until symptoms of severe circulatory collapse occur as a terminal finding, but as Wilson<sup>28</sup> and associates have stated, "Such factors as anhydremia, changes in blood chemistry and bacterial infection have been excluded as primary or essential etiological agencies."

The *third stage* or that of *repair* usually covers the time from which toxemia has subsided until healing is complete. Late deaths occur in this stage from intercurrent disease. The most common complications are pyemia, bed sores, pyelitis, and nephritis. Rarer ones are septicemia, erysipelas, tetanus, and secondary venous hemorrhage. Amyloidosis, terminal pneumonia, and peritonitis also take their toll.

So much has been written on the treatment of burns and so many different methods have been presented that the literature is likely to confuse the average reader. One source of confusion, in our opinion, has been that the patient's general condition has been considered too largely to depend upon what was done to the burned surface when actually the original damage on the surface had already produced many changes in the organs and circulatory and nervous systems with far-reaching effects and complications.

Another cause of confusion and inadequate treatment is the assumption in some articles that some one form of local treatment or general treatment will satisfy all requirements, when in reality indications may change within a few hours.

In order to avoid confusion we shall divide measures of treatment into those aimed at the restoration and maintenance of the patient's general condition and the local treatment of the burned tissues; further, we shall separate small from extensive burns. To simplify the subject still further we shall try to follow definite indications based on the pathologic physiology found in each stage. Recent advances in the surgery of war burns are described, although it is realized that they may not yet have been fully tested.

*Minor Burns.*—Since small burns (those varying between one square centimeter and one twenty-fifth of the body surface) will not per se cause systemic changes in a normal individual, we shall dispose of their treatment first. However, severe effects and even deaths are reported in patients who are handicapped by cardiovascular, renal, or other constitutional disease. Full inquiry should be made of patients with minor burns concerning past history and when indications are discovered they should be treated in a hospital exactly as though they had a major burn.

In small burns, unless the heat has been severe enough to injure fatally the stratum germinativum of the skin, a few simple precautions will suffice. These, as published ten years ago,<sup>1</sup> are repeated here after being used on scores of additional patients.

“Sterilize the surrounding skin, open the dependent edge of all blisters, apply any sterile bland salve such as boracic acid ointment, cover with sterile dressing and splint any moving parts. In our experience, unless severe infection occurs, the dressings will not need to be changed oftener than at 3 to 4 day intervals. Any dead epithelium may be trimmed off at the time of the dressings.”

As a substitute for this routine in burns of the face, hands, and genitalia, the Army Medical Bulletin<sup>2</sup> suggests applying 5 per cent sulfadiazine in water-soluble emulsion and covering with fine 44 mesh gauze and a pressure dressing of several layers of cotton waste bandaged firmly over the hands. No dressing is applied to the face or genitalia. For the eyes a 2 per cent butyn ophthalmic ointment is instilled once. The patient is then warned not to rub his eyes in order to prevent corneal damage.

Too frequent changes of dressings will damage adherent injured but regenerating tissues and will greatly increase the risk of contamination. Most surfaces which appear quite deeply burned at first will rapidly epithelize under this procedure and the delay occasioned by tannic acid for other coagulation measures will be avoided.

One exception to this procedure is that of a small deep burn. In case it is established at any time that all the epithelium including stratum germinativum is destroyed, in our opinion immediate débridement of the resulting black slough should be performed, an anesthetic being employed if necessary. Following this, intensive dakinization will soon render the part ready for grafting. Much time may be saved by the surgical removal of the deep slough since, untreated, such a slough will remain in place an incredibly long time.

*Extensive Burns.*—As I stated in an article published in 1923, large burns should be considered as emergencies of the first order, demanding the same immediate attention as hemorrhage from a cut vessel. In fact, since we now know that plasma is lost so rapidly from the damaged vessels of burned tissue, this statement is the more pertinent. It is gratifying that Army bulletins and textbooks at last are speaking of "First Aid" in burns. With the development of knowledge concerning the various changes produced in the system in burns and the rapidity with which these changes may occur, we are even more strongly convinced that serious burns demand immediate attention. A few hours of delay or misdirected judgment will often determine a fatal outcome. Efforts should be directed toward the prevention of certain pathologic changes known to occur rather than toward their correction after they become established.

*First-Aid Measures.*—When, as is sometimes the case in home or war burns, a considerable delay in getting the patient to the hospital is expected, the patient and everyone around him should be warned not to touch the areas burned, or to talk, sneeze, or cough unless the nose and mouth are covered with a handkerchief or other mask. The physician should immediately administer  $\frac{1}{4}$  to  $\frac{1}{2}$  gr. of morphine by hypodermic and, if possible, 500 c.c. of plasma. If the patient is already showing signs of primary nervous shock, the clothes may be left on. If not, they should be cut carefully at the seams and removed, being as cautious as possible to prevent contamination. No blisters should be opened. Two sterile sheets may then be wrapped about the patient and blankets applied over the sheets. The patient should be kept reasonably warm but not too warm because circulatory collapse may result. If sterile sheets are not available, ordinary clean sheets may be soaked with rubbing alcohol for twenty minutes, rinsed in running tap water, and applied damp. In simple first aid no ointments or skin antiseptics should be applied. If these measures are carried out early and the patient is assured that many large burns get along well when properly treated, no handicap in further treatment will be encountered when he enters the hospital.

*General or Systemic Treatment.*—In every large burn, on entrance to the hospital, unless shock is already too profound, clothes should be removed and an estimate made by Berkow's tables (see Systemic Reac-

tion) of the percentage of the body surface involved and the depth recorded. Morphine should be given in sufficient doses and repeated often enough to relieve pain. Care, however, should be exercised not to give overdoses because too great a depression of vital centers will result. Tetanus, though a rare complication, should be considered a distinct possibility in those deep burns in which contact with the ground has occurred. In these, tetanus antitoxin is definitely indicated.

In the primary stage measures should be taken at once to combat secondary shock which will begin in twelve to twenty-four hours and which may result in blood concentration. Each patient's case must be individualized and followed closely to discover progressive changes in his physical and laboratory findings.

*Administration of Fluids to Prevent Hemoconcentration.*—One should not wait for hemoglobin or hematocrit determinations to indicate a dangerous level of blood concentration. However, such determinations may aid in the amount of plasma or other fluids to be administered. The Committee on Surgery of the National Research Council<sup>5</sup> gives the following rule: "For each point that the hematocrit is above 50 per cent cells, 100 c.c. of plasma should be slowly injected." They recommend also that if a burn involves 10 per cent of the surface 1000 c.c. of plasma should be given during the first twenty-four hours; If it involves 20 per cent, 2000 c.c. These workers feel, and we agree, that the administration of large amounts of normal saline solution will intensify edema, that administration of this and other fluids including glucose should as a rule not exceed an amount equal to plasma, and that water by mouth and food should be moderate until the stage of shock is passed and the stomach is retentive. We do not feel that whole blood transfusions are harmful if plasma is not available. Before plasma came into common use we found them very valuable. Whole blood is valuable if the patient is found to have been anemic or debilitated before being burned or if hemorrhage has occurred from a wound at the time of the burn.

*Prevention and Treatment of Secondary Shock.*—It is to be pointed out that during the period of secondary shock an aggravation of symptoms such as vomiting, elevation of temperature, lowering of blood pressure, and weak and thready pulse indicate the development of an acute toxemia designated by Harkins as a "third stage acute toxemia." In our discussion this is regarded as simply an aggravation of symptoms of toxemia already present.

*Adrenal Cortical Extract:* Harkins<sup>8</sup> states that this substance "offers more promise in the treatment of burn toxemia than any other remedy." His excellent summary of the literature is followed and acknowledged here. Introduced for the treatment of shock in burns complicated by fractures, in 1933, by Bannick, its use was reported by Wilson, Rowley, and Gray in 1936. They report recoveries from collapse in three out of four cases treated in Edinburgh. Harkins reports a severe case in which the patient was treated with cortate or synthetic desoxycorticosterone



acetate,\* intramuscularly, every four hours for five days. In this case there was no shock at any time. Ivory, in 1940, also reported favorable results of the extract in four cases from the Hindenburg disaster.

Cope and Rhinelander<sup>70</sup> used adrenal cortical extract† on two patients severely burned in the Coconut Grove fire. The first had 70 per cent of the body surface burned and suffered severe pulmonary damage from inhalation. He received the extract intravenously approximately seventeen hours after injury. The second, with 22 per cent surface burns and pulmonary edema from severe inhalation burns, received two doses intravenously about fourteen hours after injury. Both had a fatal outcome. While these authors admit that these cases were a severe test, they feel that there was "no clinical evidence that the hormone in any way influenced the course of the disease." They state that they have treated selected burn patients previously in the hospital with the cortical extract and that "no unequivocal benefit has been obtained from its use."

Apparently from Rhoads, Wolff, and Lee's<sup>8</sup> work, the action of the cortical extract is to restore the capillary walls to their normal state of permeability and thus to prevent protein loss.

Melvin<sup>8</sup> and his associates recommend its use in the form of eucortone for 100 hours after the burn, 1 c.c. every two hours for a child and 2 c.c. every hour for adults. They believe that until the extract has been used on more cases and is on a surer basis, it should be considered as an adjuvant measure and not as a substitute for proved and recognized preventive treatment in toxemia and burns.

During the secondary or toxic stage, adrenal damage may lead to hypo-adrenalinemia, as mentioned before, according to Greenwald and Eliasberg. This may lead to marked hypoglycemia. They feel that epinephrine should be given frequently in this stage and that at the same time glucose should be given along with large amounts of fluid. We have had two such cases in children with marked hypoglycemia. One with a blood sugar finding of 17 died in spite of the administration of glucose and insulin. The other recovered. It is our belief that many patients may be saved by keeping fairly frequent determinations of epinephrine, glucose, and (as we shall show) serum or plasma chlorides.

We have quoted the work of Lowdon, Underhill, and Bigger, who showed a lowering of the plasma or serum chlorides in the secondary stage. The latter relieved toxic symptoms in patients by administering hypertonic saline solution intravenously. When blood determinations show this state to exist, certainly chloride should be administered, but one should always remember to give sufficient fluid with it to prevent too great a loss of fluids through its diuretic effect. If isotonic or normal solution of saline are to be administered, they should be given in the form of gum saline in order to prevent edema at the burned site and the washing out of serum proteins from the circulation.

\*Produced by Schering Corporation.

†Produced by The Upjohn Company.

*Anoxia.*—If the patient develops anoxia and is found to be cyanotic, oxygen should be given at high concentration in a Boothby-Lovelace-Bulbulian mask.

*Determination of Chemical Changes in Blood.*—Certain tests which are routinely employed in departments of biochemistry and pharmacology are referred to here in the hope that they will encourage others to report their findings. From this it is hoped that the present conflicting opinions concerning blood findings may be resolved and that therapy in the future may be put on a firmer basis.

*Epinephrine.*—Although colorimetric tests have been described for epinephrine, these, on the whole, have been misleading. The amount of epinephrine in the blood is determined on the iris of the sympathectomized cat. The reaction is compared with that given by a known standard and the unknown is diluted until the concentration is determined. The determination of epinephrine, especially late in the course of the burn, should be made fairly frequently in order to administer it in the blood stream if necessary.

*Adrenal Cortical Hormone.*—Cope, Nathanson, Rourke, and Wilson<sup>71</sup> consider 17-ketosteroid excretion to be an index of adrenal cortical function. They took the proved increase of these steroids in the first days after a burn to mean increased cortical activity and the subsequent decline, a lowered or depressed activity.

*Serum Chlorides.*—Serum chlorides are determined by the Van Slyke-Sandroy open Carius method.<sup>72</sup> This is modified by adding 1 to 2 drops of strong KOH to 1 c.c. of serum and by evaporating to dryness before digesting.

*Blood Sugar.*—Blood sugar is determined by the Miller-Van Slyke method.<sup>73</sup> Since the indicator called for is no longer available, a new indicator called o-phenanthroline is used in the form of a ferrous complex.\* The test is done in transmitted light which helps one to note the end point.

*Systemic Chemotherapy.*—Since the danger of contamination is so great and infection so common in burns, measures to combat infection with its attendant added toxemia should be carried out from the start. Whole blood in small quantities is a definite aid in lessening the chance of infection and in secondarily building up the patient's hemoglobin percentage and red blood cell count. Already sizable series are being reported in which sulfanilamide, sulfadiazine, or sulfathiazole has been used by mouth with great reduction in infection. Wilson and his co-workers give sulfanilamide orally as a prophylactic measure beginning the third day and stepping the amount up at the first sign of fever.

Since vomiting occurs from the toxemia of a burn and this is likewise a sign of the patient's sensitiveness to a sulfa drug, it is obvious that if one of the drugs of this group is used, its concentration in the blood

\*This may be obtained from the G. Frederick Smith Chemical Company, Columbus, Ohio.

stream must be watched very carefully. The use of these drugs is hazardous in burns when blood levels are not very carefully watched.

*Maintenance of Nutrition.*—During the stage of recovery, systemic treatment should be directed toward providing adequate nutrition to combat anemia and loss of weight. A high caloric diet, rich in proteins, will help greatly. Vitamins must be supplied in sufficient quantities also. Two standard multivitamin tablets daily will suffice to satisfy average needs. Fairly frequent blood transfusions and iron preparations should be used to combat the anemia so common in this stage.

In order to illustrate the importance of maintaining nutrition in burns we cite one recent case in which the patient survived the Cocoanut Grove fire in Boston. This patient had more than 50 per cent of his body surface burned. He has been given 6,500 calories daily—a large portion of it through the intravenous route. His daily caloric intake was said to equal about three pounds of meat. At the time of this communication he is still doing well and grafting is already being done. His physicians, Dr. Charles C. Lund and Newton C. Browder, feel that the nutritional treatment was the most important single fact in his management.

*Local Treatment.*—As has been stated under Pathology, Bardeen and Weiskotten found many severe pathologic changes in the organs of extremely burned patients as early as four hours after injury, these changes resembling those caused by a toxin like a diphtheria toxin. From this, two facts are self evident: One, that burns should be treated immediately like other surgical emergencies, such as hemorrhage; the other, that in many burns which are seen by the surgeon hours after the injury the treatment of the patient's general condition may have become of greater immediate concern than that of his burned surface, no matter how important the latter still may be. No local treatment can abolish the effect of absorption of toxins into the circulation or blood concentration from edema and fluid loss after these changes have occurred. While the literature on treatment of the burned surface is crowded with a perfect maze of new and unofficial substances and combinations of substances, we believe that we can show that one increasing purpose runs through it all. On the whole we feel that progress is becoming surer now that some of the fundamental facts concerning the burned surface have become known and the principles guiding our management of its needs are better understood. We do not plan to reiterate all of the data concerning various treatments proposed, but rather to suggest principles and apply them in such a way as to discover, amidst a host of essentials in the literature, which method or methods at present come the nearest to satisfying the best indications of local treatment.

There is every reason to believe that tissues traumatized from heat have much in common with similar tissues injured from other causes. It is likely that whatever the cause of damage to cells, a shock-producing substance or substances are liberated from them; in fact, my colleagues, Brooks and Blalock, have shown that changes in the suprarenals similar

to those in burns are also produced by trauma to muscle and by hemorrhage into tissues. It is well recognized among clinicians that severe superficial contusions, rough handling of muscle, or movement of loose ends of bones between injured muscles during transport of fractures produces shock which cannot be entirely explained on a basis of primary overstimulation of nerves.

Burned or scalded tissues may be considered to differ from extensive deep lacerations only in the fact that in the burn there is more devitalized and especially more doubtful tissue. In the burn, because of the variability of exposure of different parts of the skin surface and the protective action of underlying vessels in rapid convection or diffusion of the heat, the amount and depth of damage are usually very variable and hard to estimate at different points on the surface. The depth of damage from bomb flashes and explosions such as that of the Hindenburg are particularly difficult to estimate. Unlike deep laceration where the rule (at least before sulfa therapy came in vogue) was early complete débridement of all dead tissue in burns, it is certain that unless charring has occurred this procedure will result in loss of much valuable regenerative tissue. Another difference from the lacerated wound is that in a burn the coagulated surface tissues may be used to protect temporarily the deeper tissues from infection.

*Principles Underlying Local Treatment.*—Keeping these facts in mind a few principles which seem self-evident should be applied in the treatment of a partly burned surface.

1. Cleanse the surface and get rid of dead and devitalized tissues as soon as is safe.

2. Prevent absorption of toxin from the surface by chemical surface coagulation, pressure, or physiologic vasoconstriction.

3. Provide covering in order to:

- prevent exposure of sensitive nerve endings and damaged epithelium to injury

- prevent excessive heat loss

- prevent leakage of plasma from damaged vessels to the surface and into tissue spaces

- prevent further contamination

- contain antiseptic for combating infections

4. Put the part at rest in the position of function until movement is indicated.

All of these principles may be condensed into three:

1. Protection and rest for the damaged part

2. Obliteration of capillary exchange at the site of injury

3. Antisepsis

It is our belief that the method of treatment which applies these principles in the fullest degree will give the best chances of recovery with minimum loss of function.

It must be recognized, of course, that burns must be individualized for treatment to do the most good. Thus, it is well agreed that tannic acid should not be applied after twenty-four hours, and that burns of the face, hands, and genitals do very badly when tanned; likewise, that transparent jackets may be used to greatest advantage on burns of extremities.

*Evaluation of Methods of Local Treatment.*—No matter what later procedure is to be carried out, burned surfaces should be cleaned as early as is compatible with the patient's general condition. The procedure recommended by Owens<sup>43</sup> is as follows:

"The surgeon scrubs and drapes the patient as if for an operation. Using only morphine for analgesia, the burned areas are then washed with thick suds of bland white soap, sterile water and large pads of absorbent cotton. A gentle rotary motion is used in the cleaning process." He then adds the details of débridement by sharp dissection. To these details of cleaning of the entire area I would add that the soap suds should be thoroughly washed off with an abundance of normal saline solution and that then the surrounding skin should be dried and painted with some good skin antiseptic like aqueous zephiran, metaphen, or merthiolate.

From this point on, opinions are at great variance as to the best time to accomplish the remaining part of Principle 1 or débridement.

*Immediate total débridement* under anesthesia, as advocated by Willis, would be ideal for prevention of toxemia, but has been largely given up because of considerable operative risk and because islands of epithelium in hair follicles and sweat and sebaceous glands may be sacrificed which might have been saved. A cautious débridement under morphine only, as practiced by Owens, largely obviates these disadvantages.

*Delayed partial débridement* was first employed by us in 1934.<sup>1</sup> This consists in delaying the removal of damaged tissue except dead epidermis until sloughs have become definite. Then as large a portion as it is felt the patient can tolerate to have removed is surgically excised at one operation under nitrous oxide-oxygen anesthesia and this area is dakinized. This process is safely repeated with skin grafting at the site of each previous excision until the patient is entirely healed. In our cases this procedure has proved safe for both the patient and his tissue.

To carry out Principle 2 and prevent absorption of toxin from the injured tissues, several methods have been designed as follows:

(a) *Mechanical Pressure.*—The method of controlling or partially blocking capillary interchange and therefore of limiting absorption by mechanical pressure was discussed by us.<sup>45</sup> in 1923, as follows: "I first considered employing light pressure interrupted by periods of relaxation, as a means of exerting a tourniquet action on the capillaries, but the

technical difficulties of applying inflatable rubber jackets or of immersing insulated patients in heavy solutions have made other methods of treating patients more valuable clinically."

It is interesting that in the use of hypertonic saline tubs or baths, as popularized by Blair and Brown, a certain head of pressure is exerted for the tub period of the patient's routine, although this element of pressure is not mentioned by the authors as a factor in the treatment. At the point of deepest immersion this might reach a head as high as 35 cm. of salt solution (more of water), which figure approaches normal capillary pressure.

In lieu of tannic acid, the Committee on Surgery of the National Research Council advises a pressure dressing over an appropriate antiseptic dressing for the hands, and Owens,<sup>43</sup> in his outline of treatment of burns after early or late débridement, applies (over a first layer of 44 mesh wet gauze and a heavy dressing of mechanics waste and a layer of cellophane) a three inch roller bandage with "considerable pressure."

(b) *Coagulation of Proteins on the Surface by Chemicals* (Tannic Acid).—Many substances have been advocated for this purpose since Davidson published his masterful articles on the subject of tannic acid. While for some it has been claimed that there is less likelihood of troublesome infections under the crust, for none has a better membrane been claimed. The author summed up its action in these words, "It precipitates proteins, alkaloids, some glucosides and the salts of heavy metals. It forms a more or less stable compound with the protein constituents of the body fluids and cells. When applied to a burned surface in dilute solution, further penetration into the deeper lying protoplasm is apparently prevented by this action and the true astringent effect appears to be limited exclusively to the most superficial layers of tissue."

I still feel that tannic acid is an extremely valuable adjunct to burn therapy at the war fronts, although I feel that its use is contraindicated in burns of certain depths (third degree) and certain locations (face, hands, genitals, and feet). There is no longer any question of its great reduction of mortality in the period of toxemia over ordinary dressings. Thus, the contention of Davidson that the toxin of whatever nature is locally precipitated and held in the membrane appears to be borne out. That this decreased mortality is not due to prevention of infection is shown by the rapid return of toxic symptoms when wet dressings are applied to the membrane.

If all burns were superficial and could be treated by Davidson's simple gradual tanning specifications, results, while slowly obtained, would be excellent. Davidson warned against deep caustic action of strong solutions which tanned in a short period of time. On the face, because of the eyes, tannic acid is dangerous and the membrane on hands and fingers, on account of the immobilization produced for so long a time, is disabling. On deep burns the tannic acid membrane may imprison

organisms which produce deep burrowing infections. Consequently, its use is not desirable in such cases, particularly since the membrane will have to be excised before grafting is done.

*Tannic Acid-Silver Nitrate.*—In 1935, Bettman introduced the addition of 10 per cent silver nitrate to the initial application of 5 per cent tannic acid to hasten the tanning and, as he claims,<sup>47</sup> to save lives that would otherwise be lost from absorption of toxins, hemoconcentration, and infection if a slower method were used. Tannic acid-silver nitrate treatment is recommended for use except on face, hands, and genitals by the Committee on Surgery of the National Research Council.<sup>48</sup> Harkins<sup>50</sup> feels that "one advantage of the method cited by Bettman is rather difficult to prove; namely, that the use of tannic acid plus silver nitrate over a short period of time is less destructive to skin islands than is the use of tannic acid alone over a period of time. It is possible that a lessened incidence of infection might account for such results. He quotes Aldrich as saying, "The disadvantage of using silver nitrate is that it converts every second degree burn into a third. Exposed injured dermis cannot stand being in contact with silver nitrate. An epithelium that would live and spread is destroyed by this method." Bettman claims just the opposite, namely "stimulation of epithelization" and "less skin grafting."

Many other substances, most of which are antiseptics and will precipitate proteins such as gentian violet and many other dyes will be discussed under Principle 3.

(c) *Prevention of Absorption of Toxins by Physiologic Action, Namely by Vasoconstrictor Drugs.*—In an article in 1923, on "Restriction of Rate of Flow and Interchange in the Capillaries" we showed that the absorption of injurious substances could be prevented, especially in superficial burns, by vasoconstrictor drugs, notably epinephrine. Through the work reported in this and a slightly later article, it was proved experimentally and clinically that prompt and lasting (seventy-two hours) restriction of the rate of flow and interchange in capillaries may be produced over large burned surfaces devoid of epithelium by constant or intermittent local applications of vasoconstrictor drugs, notably by epinephrine, in very weak solution. Locally applied, it was shown that epinephrine will very largely, if not completely, inhibit its own absorption by direct action on the most superficial vessels not severely injured. Its use was suggested for the purpose of preventing absorption into the general circulation at any one time, of a dangerous quantity of symptom-producing substance from the surface. Following this, we showed that epinephrine chloride in concentrations harmless to tissues would stop or greatly inhibit absorption of various dyes, crystalloids, and alkaloids, as well as soluble bacterial toxin and cobra venom from abraded or wounded surfaces of animals.<sup>52</sup> It was demonstrated that animals with very extensive burns (35 to 40 per cent)

would survive with a minimum of shock when treated with moist epinephrine compresses 1:8000, while controls treated with normal saline solution would die in twelve to eighteen hours. Underhill and co-workers<sup>53</sup> showed in experimental burns in rabbits that when strychnine is injected into the burned area up to an hour following the burn, it is rapidly absorbed and produces convulsions. After this latent period during the next seventy-two hours, absorption of strychnine and phenolphthalein is present but slower than under normal conditions. This they took to mean that capillary permeability was increased early, giving rise to rapid absorption and later it is increased in the outward direction "so that substances pass more readily than normally from the capillary to the wounded area giving rise to edema" which slows up absorption.

This work serves to corroborate ours in showing that surface absorption must be very rapid in the first period after a burn and that the latter, for this reason, constitutes an emergency which should be treated at once. It also shows that absorption, while slower from an edematous mass than from uninjured tissues, may still be appreciable over a period of time. With epinephrine applied to the surface capillary permeability and exchange is diminished from the start. Fig. 1 shows how heat, even at a distance, opens human capillary loops and how epinephrine closes them.

Several children with burns as high as 25 per cent of the total body surface were treated with local epinephrine compresses.\* In these, adrenalin chloride 1:8000 was injected through Carrel tubes to soak light gauze packs covered with cellophane. Toxemia was strikingly absent in these cases and all survived. That the epinephrine was effective after twenty-four hours was shown by washing it off with saline solution and after two hours painting a figure 2 on the then red area with fresh epinephrine on an applicator. The figure 2 then stood out blanched against the red background. After forty-eight to seventy-two hours, concentrations of epinephrine were diminished gradually to 1:24,000, at which point saline solution was substituted without the development of toxemia. The tapering off prevented the development of capillary hemorrhage which, while rarely of any significance, might occur if the epinephrine effect was suddenly interrupted. Dr. C. A. Mills, who studied the blood chemistry on these cases, showed that so little epinephrine was absorbed that the only change detectable was a slight increase in blood sugar. It was, however, pointed out that the carbohydrates should be continued to avoid the late hypoglycemia which may develop due to adrenal damage in any patient with burns. The use of epinephrine was thought to be contraindicated and was not used in patients who had hyperthyroidism. Reports of this and further work were published in two articles.<sup>12, 55</sup>

McCollum<sup>57</sup> reports the use of this method in several European clinics and states that he has applied epinephrine to fresh burns with . . . "a

\*On the Pediatric Service of the late Dr. Kenneth Blackfan at the University of Cincinnati.



reduction in the amount of tissue fluid loss." He feels that the absorption of any toxic products in the burned area is thereby kept at a minimum. He finds that "the amount of adrenaline absorbed is also very small because of the local constriction of the vessels."

Epinephrine has no broken-down or oxidation products which are toxic. Its bacteriostatic action on common pyogenic organisms has been reported. Burned areas which have been treated by us experimentally and clinically have remained remarkably clean and their healing has been very satisfactory. In the early days the expense of the continuous use of epinephrine on such large gauze dressings over burns for three days proved very great. A less expensive way in which to use it was sought so that it might be employed more widely. It is felt that our work of perfecting transparent jackets, to be described, has accomplished this. For the first time, with these Theraseal jackets small quantities of weak epinephrine solution may be made to affect large surfaces for long periods without waste, because they are sealed in an airtight jacket.

*Provision of Covering.*—This leads us to Principle 3, namely to provide covering, the accomplishment of which serves to prevent further contamination, to prevent exposure of nerve endings to injury, to prevent excessive heat loss, to lessen loss of plasma from damaged vessels to the surface and into tissue spaces, and, if desired, to contain an antiseptic for combating infections.

Many types of covering have been suggested, from bland ointments of boric acid covered by fine gauze mesh as employed at the Massachusetts General Hospital on the Cocoanut Grove victims, to the more complicated methods of coagulating the surfaces to form an adherent form-fitting encasement. Then we have the method of alternating dressings with hypertonic saline immersions in tubs.

Although we are aware of the fact that in some clinics cleaning of the fresh burn is omitted, we still believe that there is less of an aftermath of infection if simple cleansing measures are carried out, as outlined, as soon as the patient's condition warrants.

In the matter of dressings we feel that the trend is definitely away from frequently changed dressings as occasioned by soaking in tubs or by ambrine technique which requires a tremendous amount of time on the part of the medical and nursing staff, and toward more occlusive, longer enduring coverings with less frequent changes.

Coagulating or tanning methods, such as furnished by tannic acid alone or in combination with silver nitrate, various dyes such as gentian violet, acriflavine or combinations of these, all form covering membranes of varying degrees of thickness and flexibility. Some of their advantages and disadvantages have been discussed under Principle 2. With the tanned membrane present it is true that no other covering except a moderately heated cradle to exclude air from the body is required and further contamination, heat loss, and leakage of plasma from the surface is pre-

vented. Nevertheless, because of the hardness of the eschar or membrane, deep infections may be masked under its surface. Another disadvantage is that healing or reparative measures may be delayed by the slow separation of the membrane. We have pointed out its dangers when used on the face, hands, and genitals.

Other substances, such as gentian violet and triple dye (brilliant green and acriviolet) also form covering membranes but these membranes are much thinner and more pliable than the tannic acid membrane. Also they have the proven advantage of being antiseptic, which reduces the incidence of infection. If pus forms under these membranes it dissolves the latter and breaks through. I have had the opportunity of following burns treated by gentian violet and triple dye and feel that both are of definite value. Leriche<sup>8</sup> feels that because of its antiseptic power, mercurochrome is the dye of choice for infected burns. One drawback to all dyes is that they stain and ruin almost every article with which they come in contact. Although a minor objection, this is a very real one.

Probably the reason that the Committee on Surgery of the National Research Council recommends tannic acid-silver nitrate as one method for treating most burns is that this offers an easy, quick, fairly safe method which can be carried out well with light materials in the field and which saves dressings.

Antiseptics used in treating burns besides the ones mentioned previously are the sulfa derivatives and Dakin's. Pickrell<sup>9</sup> claims to have obtained excellent results with a sulfadiazine spray which does not stain or coagulate. This drug, sulfanilamide in solution, and Dakin's solution are the drugs which have proved most useful in the cleaning up of infected surfaces before grafting.

Wet dressings are very uncomfortable unless cover is provided over them. Cellophane over gauze is one form of cover which has been used for years. Transparent jackets without gauze are by far the most modern form of covering. The development of this form of dressing together with its clinical application which has been described in three previous articles is now given in greater detail.

#### THE TRANSPARENT JACKET SYSTEM

*Development.*—My observations on the avoidance of secondary infection in acute pleural empyema by the use of closed methods in contrast with open methods of drainage, as well as other observations on the effect of pressure on the peripheral blood vessels in preventing absorption from wounded surfaces, led me in November, 1935, to develop a new method of treating extensive burns and other wounds in which the conclusion from both studies could be clinically applied.

The apparatus first employed consisted of a rubber jacket. A few weeks later jackets of specially made transparent rubber were used. In 1937, completely transparent jackets of Pliofilm\* were employed and

thin but rigid cylinders of cellulose acetate were used for skin grafts. When pliofilm became scarce because of rubber shortage we adopted the more durable miracle glass plastic Krestex cloth which is also transparent.

The first patient was treated by this jacket method in early December, 1935 (See Case 1, Fig. 2D). The second patient was treated during the same month (See Case 2, Fig. 2A, B, and C). Both patients had burns which were treated by skin grafts within the jackets. Results on both were very satisfactory.

*Literature on Jacket System.*—A preliminary clinical report of the jacket system of treating extensive wounds was given at the Vanderbilt Medical Society, March, 1936, when transparent jackets were shown for the first time and this was reported in April, 1936.<sup>59</sup> As in any new work, the clinical apparatus was difficult to obtain at first. Thus, much time and effort were used in getting the jackets properly made. The first step was the perfecting of a transparent material which would be soft, pliable, strong, chemically resistant, and fabricable into the various forms required.

I was able,† in February, 1936, to have made a slightly yellow-tinged, but completely transparent, rubber sheeting of which I made many satisfactory jackets. These served the purpose well until 1937, when I obtained‡ a supply of extra thick pliofilm which was colorless and even more transparent than the rubber material and which could be stuck together permanently at the seams by heat or cement. Inlet and outlet tubes were fitted hermetically at different points through the material by compression washers such as those used in fitting a valve to a bicycle tube. In others, rubber or plastic tubes were sealed into the jackets as outlets.

Realizing, in 1937, that the treatment of wounds within the jackets presented many new and interesting problems which needed study, I obtained a grant for this purpose from the Committee on Therapeutic Research of the Council on Pharmacy and Chemistry of the American Medical Association. As our experience increased, additional problems presented themselves which have been thoroughly investigated. One of these was the determination of the effect of pressure within the jackets to skin grafts. It has been found, by placing a mechanical stage within one of the jackets, that sufficient positive pressure can be applied to a piece of moist skin placed on the stage to hold it firmly in contact without the employment of sutures. The pressure is exerted equally over the entire surface and would be maintained for a period of time. If for any reason the pressure should be lost, it can be regained by interrupting its source and applying it again.

\*Produced by Goodyear Tire & Rubber Co., Inc.

†Through the kindness of Mr. Willard P. Silberling of the rubber company which bears his name in Akron, Ohio.

‡Through the kindness of Mr. Erikson, of the American Hospital Supply Corporation of Chicago.

In the past the status of the treatment of extensive wounds from burns, frostbite, and mechanical trauma has been very unsatisfactory. The mere mention of them usually brings to mind many unpleasant sessions when the removal of massive dressings soaked with fetid pus resulted in almost unbearable pain and frequently caused a considerable loss of blood to an already debilitated patient.

Step by step, surgeons have been persuaded to adopt methods which will make the dressings of such surfaces less frequent and less painful. The Schede blood-clot operation for osteomyelitis was perhaps the first step in this direction. Then came Halsted's use of gutta-percha tissue to prevent the sticking of a wound to the dressings. Later came the direct application of elastic adhesive to an ulcerated surface with infrequent dressings, advised by Wright,<sup>64</sup> and others. Still later we come to the doctrine of Orr<sup>65</sup> of the treatment of osteomyelitis and other wounds by drainage and rest. In his first book on the subject we find the following statement, "If dressings are done at intervals of several weeks instead of daily, it is quite possible for the surgeon to give the necessary time to see that his original ideas in regard to the position of the limb, splints, apparatus, etc., are strictly carried out and to have the dressings done under his own eyes so that proper rules of technique and aftercare are strictly observed." I quote this author further in saying:

"The different effect on the wound itself is shown by the fact that upon examining the wound for the first time two or three weeks following operation, there is found to be usually less discharge than is found at each dressing when they are changed frequently. This seems to explain why the absorption is less also when the infrequent dressing method is employed."

And further, "Among the advantages which should be emphasized for the treatment of these conditions by drainage and rest alone, none is more important than the relief afforded the patient."

Again I quote Orr as saying, in 1930, in Detroit, "Do not disturb the wound or the part except for definite complications."

Treuta's<sup>66</sup> success in treating compound fractures and other war injuries in plaster casts left on for long periods is but another link in the chain of evidence that a closed method with very infrequent dressings is of definite value.

One may easily see from the trend of all these opinions that the teaching of modern surgical thought is away from frequent dressings especially of the porous type, and toward infrequent ones of a type relatively impervious in the inward direction, which cause less pain. Perhaps the greatest danger in the new era is that the surgeon, in his knowledge that less frequent dressings are advantageous, may overlook complications until grave symptoms have developed. In my own experience, however, this latter occurrence has been very rare.

In an article in 1930,<sup>67</sup> in speaking of the advantages of closed methods of drainage over the open methods for treatment of acute pleural em-

pyema, I wrote: "It (the closed method) seals the pleural cavity and does away with the inconvenience of frequent dressings and the danger of secondary pleural contamination; . . . and it eliminates the development of chronic empyema from acute cases. . . ."

It is an arresting thought that the great development afforded the surgical field in the realm of asepsis in operations by the use of rubber gloves, first by Bloodgood and Halsted at Johns Hopkins, in simple terms consisted of jacketing the operator's hands so as to keep contamination from the freshly damaged tissues. Is it not as important, or even more so, to jacket a wounded hand or other part of the body from the many sources of contamination to which it would otherwise be exposed? Was not Lister's main idea that no extraneous organisms be introduced into a wound during surgical proceedings? Our very first patient treated in this manner was a child whose injured hand was encased and sealed safely in a large rubber glove. All later forms of jackets involve the same fundamental principles but add the convenience of transparency. In all, the protection afforded the part is basic.

The present jackets we employ all make frequent dressing unnecessary and even undesirable and likewise make the development of unseen complications, such as the deep abscesses which may arise under a surface tanned with tannic acid, very rare by keeping the wound surface under clear vision, soft and palpable at all times.

*Résumé of Work on Capillary Blocking.*—From records of experiments my work along this line dates back to 1920. In an article in 1923, this statement is made, "I first considered employing light local pressure interrupted by periods of relaxation as a means of exerting a 'tourniquet' action on the capillaries, but the technical difficulties of applying inflatable rubber jackets or of immersing insulated patients in heavy solutions have made other methods appear more valuable clinically." Many years after this I found out that in 1834, Junod had applied an inflatable boot of glass and copper with a broad rubber ring at the upper edge to shut off air. His purpose in using them, although not clear, was not for treating wounds.

The development of light transparent jackets removed the difficulties which at first we thought might be insurmountable and which forced us to use vasoconstrictor drugs alone to accomplish the desired constriction of the vessels.

From the work described in the article mentioned previously (1923)<sup>12</sup> and in subsequent published work carried out in France, we have shown clearly the influence of capillary constriction in preventing absorption of toxins from large burns or otherwise traumatized surfaces. The later work of Blalock on shock, proving that the escape of plasma from the capillaries and other small vessels into the traumatized tissues is of great importance in producing the symptoms in burns and extensive wounds, serves only to make more significant the use of the jackets which,

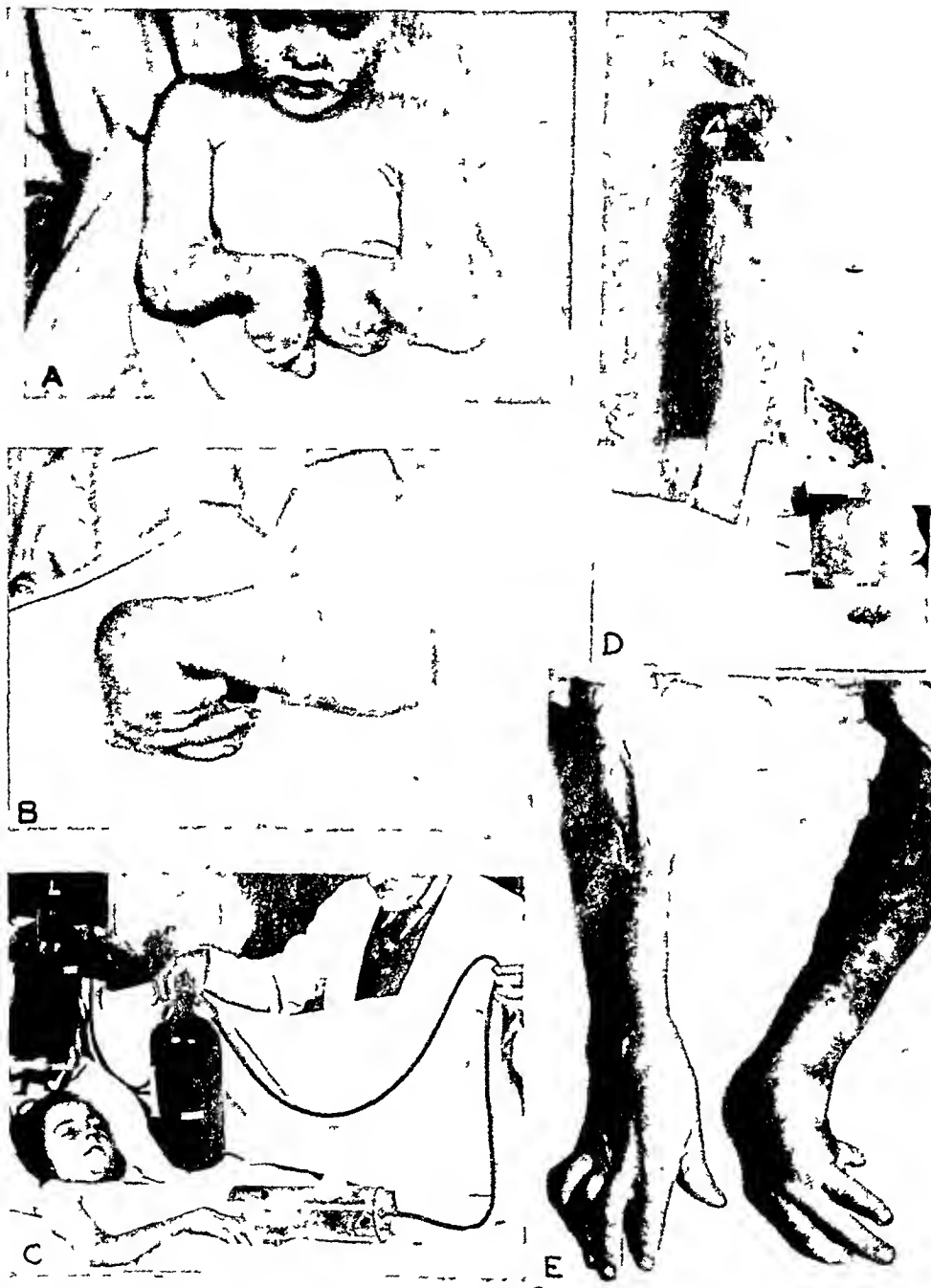


Fig 3 (Case 1) —A, Deformity of joints of upper extremities B, Degree of possible extension of left elbow before operation C, Application of pressure within transparent jacket to skin graft of left hand Head of air pressure represented by difference of white marks on water bottles D, Shows complete take of full-thickness graft on palm at time of removal of hand from jacket E, Shows result of various operations for relief of contractions

while protecting the surface, allow an even and easily regulated increase of pressure on the capillaries with or without the addition of vasoconstrictor drugs within them.

The difficulties and excessive cost of applying epinephrine in effective concentrations to large wounds due to evaporation and oxidation have been a stimulus to the development of the transparent jackets. The latter, in preventing oxidation and drying, makes epinephrine more efficacious in preventing exudation of plasma and absorption from the burned surface, the effects of both of which often prove fatal in large burns.

Another line of evidence that vasoconstriction accomplished by pressure or chemical action is advantageous is to be found in the effect of a pressure bandage such as elastic adhesive when applied to a wound. In a recent article<sup>68</sup> I have shown that this bandage usually rapidly reduces the number of microorganisms until sterility is reached.

I have shown still further in a second article<sup>69</sup> (with the help of Doctors Schrek and Avery) that an ulcer becomes sterile much more rapidly when covered with elastic adhesive directly without gauze than does a similar ulcer on the leg treated by boric acid solution and heat in the form of moist compresses. In this same report I point out that Halsted, in 1913, called attention to the advantages of maintaining moisture of the wound edges during healing in these words, "A moist scab, so-called, is better than a dry one. The surgeon has many opportunities to convince himself of this. . . . On covering the entire surface of the granulating wound with gutta-percha tissue the pain will be relieved and the inflammation subside."

"The dry scab imprisons secretion which in turn gives rise to tension and the tension impairs the vitality of tissues under and at the border of the dry scab to an extent sufficient to place them at a disadvantage with the microorganisms and to compel absorption of the toxins."

Another action of a dressing such as elastic adhesive which provides moist conditions was not specifically mentioned by Halsted. This is that by protecting the surface from recontamination or reinfection by outside organisms, the blood can locally build up at the wound antibodies definitely specific for the particular organisms present at first—in other words, the "pansement spécifique" of the French. This is an aid to rapid sterilization and thus to rapid healing.

One disadvantage of a dressing which fails to maintain moist conditions on the wound surface is that drying puts the leucocytes out of commission and must also destroy antibodies. This is emphasized by Wright in a recent article.

So clear-cut and striking have been the results of elastic adhesive on old ulcers that we may say that antiseptics of any sort appear to be unnecessary and undesirable on them. This in simpler terms means that in the future wound treatment, except in the acute phase, will depend largely on physical rather than on chemical adjuncts or aids. In the

and durable. While having a ground-glass surface, it is very transparent. Wounds are plainly visible when the jacket is held in contact with them; in fact, millimeters may easily be read on a celluloid rule through two layers of it. No acids, alkalis, or antiseptics used in surgery affect these jackets. They may be washed clean and sterilized by boiling, although soaking in bichloride of mercury 1:3000 for twenty minutes, followed by rinsing with saline solution is advised as a routine to preserve luster.

Only light oil, like sewing machine oils, will cause the jackets to deteriorate.

*Semirigid Transparent Jackets for Extremities.*—For purposes of applying constant or intermittent pressure to skin grafted surfaces on the upper and lower extremities, a slightly different type of apparatus has been developed. Transparent cylindrical tubing of cellulose acetate approximately  $\frac{1}{16}$  inch in thickness and of various diameters, with one end closed by a flat or rounded head of the same material, has been made up into jackets for us by several different companies.\* These tubes are light, durable, resistant to all antiseptics and to any temperature which is compatible with tissue viability. They will withstand far greater pressures than those ever employed for skin grafts. Plastic or metal tube connections may be seated in their walls by using the familiar arrangement of parts employed in seating a bicycle valve connection to a tube.

These tube jackets may be hermetically sealed to an extremity at a point above a wound by the type of seal shown in Fig. 6. In this a rubber cuff like that of a rubber glove, or larger, has its upper end slipped over the upper or corrugated end of the tube. The lower or thin end is then slipped over the extremity by holding it open until it seats gently at the desired level. Surgical lubricant is placed on the skin under the rubber cuff and a doughnut of rubber or gauze is inserted under the rigid end of the jacket. Three or four vertical strips of adhesive are placed from the skin to the jacket and a snug gauze bandage is applied over all. As pressure is raised within the chamber, a proportional amount will be exerted to press the seal against the arm, thus preventing leakage.

*Application of Pressure to Skin Grafts.*—When a low pressure is applied within the jackets, exudation is greatly reduced. In the case of noninfected skin grafts to which a constant pressure between 30, and 45 cm. of water was applied within the jackets, a total of only a few drops of sanguineous exudate was seen to be pressed out at the edge of the graft from the time of operation until healing had occurred. I am led by such findings to agree with Orr who, in speaking of infrequent dressings by his well-known method, says, “. . . there is found to be usually less discharge (at long intervals) than is found at each dressing

\*Hygienic Tube and Container Co., New York, N. Y.; American Hospital Supply Corp., Chicago, Ill.; Monsanto Chemical Co., Plastics Division, Springfield, Mass.



when they are changed frequently." Certainly the exudation is almost as little under optimum pressure conditions within the jacket as it would be in two clean wound surfaces held by stitches in proper appositional tension, if I may coin a term. The effect of this optimum pressure on the complete take and healing of skin grafts is beautiful to watch through the jackets.

Since we have found it easy by its use to maintain any degree of pressure on the small vessels under a skin graft or to alternate positive and negative pressures as desired, we have named this form of thin transparent semirigid jacket *Thervator* or *Therapeutic vascular regulator*. (See Figs. 3, 4, and 6.)

*Application of Thin Transparent Jackets* (Fig. 7).—By observing a few rules, the matter of applying jackets may be made very easy. If the jacket is to be used simply as a protective cover for a wet-soak dressing, which in itself is a great convenience, it is simply sterilized in bichloride 1:3000, slipped over the entire part and the drawstring tied snugly but not tightly. Irrigations are then made through the openings. When it is to be used directly in contact with the wound (method of choice), the skin is shaved and the wound cleansed or otherwise debrided. Skin and jacket are sterilized. Surgical lubricant is applied in a band two inches wide around the circumference slightly proximal to the point of contact with the upper edge of the jacket. The drawstring is tied. If intermittent irrigations are to be carried out, two small long rubber bands like those used around letters are slipped over the jacket and allowed to make slight pressure over the jacket and leg. These are spaced about one inch apart and the same distance below the drawstring. A few strips of one-inch adhesive running vertically from skin to jacket anteriorly, posteriorly, and laterally will prevent slipping. The circular rubber bands may be removed between irrigations.

If the pressure is to be applied constantly or continuous irrigations done, the jacket is similarly applied with the strips of adhesive but small bands  $\frac{3}{8}$  inch wide of thin Penrose drain material are fitted snugly over the jacket with light pressure, one inch and two inches, respectively, below the drawstring. Jelly lubricant or heavier zinc oxide ointment are placed under the edge of the jacket at the level of pressure by the rubber bands. Any excess material in the circumference of the jacket is folded on itself and the adhesive bands are stuck on as before to prevent them from slipping downward. A firm but not tight circular gauze bandage is applied over all. In our experience this type of seal has been completely satisfactory in preventing leakage. When removed, no pressure ring has resulted from the gentle pressure of the rubber band. Nevertheless, the position of the bands should be changed from time to time.

The other type of seal by infolding a rubber cuff is also very simple and will hold air indefinitely. It has been described fully under the

and durable. While having a ground-glass surface, it is very transparent. Wounds are plainly visible when the jacket is held in contact with them; in fact, millimeters may easily be read on a celluloid rule through two layers of it. No acids, alkalis, or antiseptics used in surgery affect these jackets. They may be washed clean and sterilized by boiling, although soaking in bichloride of mercury 1:3000 for twenty minutes, followed by rinsing with saline solution is advised as a routine to preserve luster.

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tanned membrane. Many pockets of pus were found under the crust, therefore the greater part of it had to be removed. On healing after pinch grafting in several stages, the condition was as seen in Figs. 3, 4 and B, Dec. 14, 1933, with the elbow joints, wrist joints, palms, and fingers all drawn up in extreme flexion contraction. Several plastic operations were required to correct all of these contractures.

At operation, Dec. 16, 1933, the contracted cicatrix of the left elbow was excised and a full-thickness skin graft substituted.

Jan. 16, 1934, the cicatrix of the right elbow which produced flexion was lengthened and the contracture relieved by a "staggered Z" plastic operation.

Oct. 15, 1935, the contracture of the left wrist was relieved by dissection and the application of a thick split graft from the thigh.

Oct. 21, 1935, the contracture of the right wrist was treated by excision and application of a thick split graft from the left thigh.

Since this report deals with the application of pressure to grafts by placing the extremity in jackets, the palmar and finger contractures will be reported in greater detail.

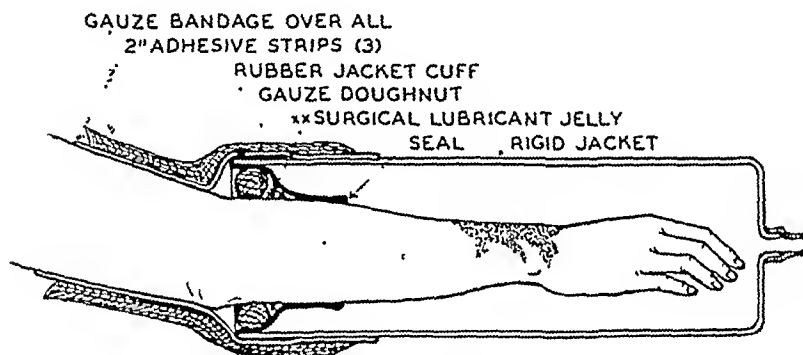


Fig. 6.—Semidiagrammatic drawing showing arrangement of hermetic seal for semirigid transparent jacket used over skin grafts. For complete description see text.

At operation, Dec. 5, 1935, the scar of the right palm which bound down the fingers in flexion was removed by mass dissection. A pattern was made after all fingers had been fully separated and extended. The pattern was divided into two parts and two corresponding full thickness grafts were removed from separate abdominal areas, the latter having the skin edges undermined and closed. The two grafts were sewed together in the shape of the pattern and were sutured with a continuous suture of silkworm gut at the edges. A hermetically sealed pressure jacket consisting of an ordinary No. 8 surgical rubber glove was slipped over the hand (see Fig. 1 D) and a seal made at the wrist by applying heavy zinc oxide and wrapping a band of rubber, consisting of a small rubber Penrose drain split in half (lengthwise), around the wrist over the glove cuff with just enough pressure to maintain contact of the cuff outside of the zinc oxide. A small glass tube was tied into one of the fingers of the glove and the glove inflated to a pressure of 20 cm. of water at which point it was maintained by water bottles. The pressure was maintained for fifteen days. The graft took, almost in its entirety. A few small areas at the edges sloughed but these rapidly healed in. The webbing of the hand and palm appeared to be relieved.

Jan. 2, 1935, by a circum-scribing incision the dense scar tissue of the palm, thumb, and fingers was removed and the contraction relieved. The denuded area was covered by full thickness grafts cut in a manner similar to that employed on

the other hand. A glove was employed for positive pressure like that used on the other hand. Except for a small area on the thumb, the graft took. The palmar surface of the hand was covered and the fingers well-separated by the graft.

Feb. 11, 1936, two staggered Z plastic operations were employed to lengthen the scar bands holding the right palm and wrist respectively.

April 3, 1936, the flexion deformity of the left wrist was relieved by dividing the scar and swinging a flap from the dorsum of the wrist anteriorly. A few small deep grafts sufficed to complete the closure of the area from which the flap had been swung. The right palm was dissected free of scar which had remained after previous procedures and a small full-thickness graft cut from the thigh was transplanted to it.

On June 2, 1939, a note was made when the patient returned for observation that there were moderate contractures of the left fourth and fifth fingers and a slight residual contracture of the left wrist. All other regions, at this time, had responded nicely to grafting, and the patient had excellent function of her hands, wrists, and elbows.

At operation Nov. 4, 1939, the left palm was opened and the contracture of the fourth and fifth fingers relieved by excision of the dense scar from them. A full-thickness graft was patterned to fit the defect and dissected from the upper abdomen. It was sutured into the palmar raw area with dermal silkworm. The hand was placed in a transparent cylinder of cellulose acetate with a rubber glove cuff above the elbow in order to hold constant pressure on the arm while keeping it free of all other dressings (Fig. 3 C). The air pressure was maintained at 20 cm. of water within the chamber for four days (Fig. 3D). The graft was entirely viable at the end of this time. A dressing of lambskin with wool attached was applied over dry gauze. This was continued during the next three weeks.

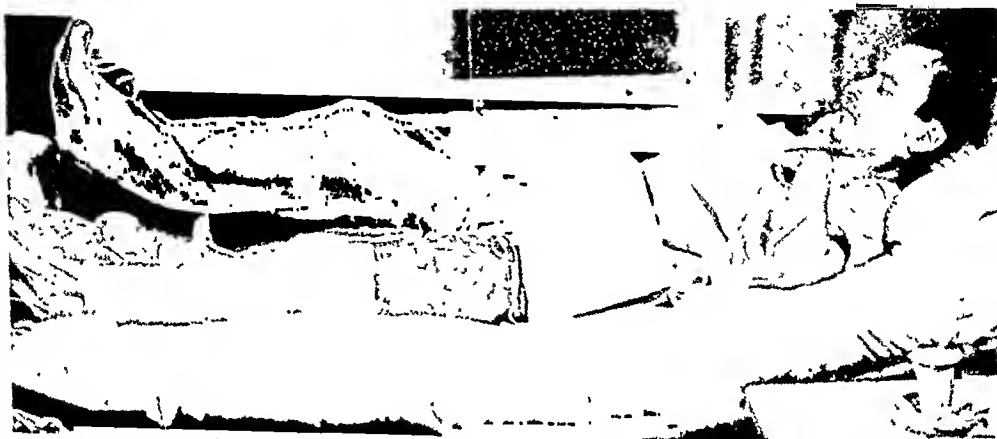
The graft was a "take" in its entirety. The final photograph shows the condition of the upper extremities as compared with their condition before plastic work (Fig. 3E).

CASE 2.—M. K., a white boy, aged 14 years, was burned six days before admission, Nov. 30, 1935, when a can of burning gasoline was kicked over and set the clothes on his right leg on fire. Examination on admission revealed a complete loss of skin from the perineal level of the right thigh to the lower ankle region (Fig. 2B). Dirty necrotic skin and white necrotic subcutaneous tissue comprised the burned area and much foul purulent exudate was present over its surface. Physical examination, except for enlarged cryptic tonsils, was essentially negative.

*Treatment and Course From Nov. 30 to Dec. 11, 1935.*—Before being admitted to this service the patient was treated by immersion, two to four hours, morning and afternoon, in warm saline solution in a bathtub, alternating with exposure of the wound to air in a lighted cradle. During this time his temperature was septic in type after the first four days, reaching 102° F. daily. Necrotic skin was débrided from the leg on Dec. 7. On Dec. 11, a sterile rubber tube was slipped over the entire wound of the leg and pinched off hermetically below the foot and likewise sealed above the wound on the thigh (see Fig. 2A). This appeared to give much relief to the patient from local pain. The temperature became only slightly higher each day, due probably to insulation, but the white blood cell count diminished. The wound exudate which collected inside the jacket gradually diminished in amount and the wound, which could be observed through a threaded cap, grew progressively cleaner. Oxygen was used under slight pressure to inflate the jacket. By Jan. 2, 1936, the exudate was less in quantity (only about 300 c.c. daily) and the specific gravity was less. The jacket was temporarily removed and a thick split-skin graft, 60 square inches (12 by 5) cut with the Blair knife and chamber, was sutured to the entire popliteal space and lateral and medial surfaces of the knee. The jacket was then readjusted and air pressure of about 42 cm. of water, gauged by

water bottles, was applied to inflate the jacket. The exudate first increased to 1100 c.c. after the operation, but rapidly decreased thereafter to between 150 and 200 c.c. daily. The graft became firmly united over all of its bed except for small areas near the patella (Fig. 2C). The jacket was removed after fourteen days and the remainder of the leg grafted with many small deep or pinch grafts in several stages. Although the patient was emaciated, his general condition was improved by frequent blood transfusions. His leg was entirely healed on discharge, April 14. He was subsequently followed as an ambulatory patient in the outpatient department after discharge.

A.



B.

Fig. 7.—A, Treatment of granulating wounds of both thighs and both legs within transparent jackets. Note vents at top of jackets with tube connections in place on right and vent at heel for drainage. Jacket on left leg is used to cover dressing and provide moist compress. That on right is used with hermetic seal for direct irrigation without any other dressing. Note transparency. B, Transparent sleeve jacket for leg and thigh with foot excluded. Note vents and seals above and below. (Photos by Tommy S. Gibson.)

CASE 3.—D. M. B. a 12-year-old girl, had her right cheek and right hand burned at 9 months of age when she fell into an open grate. The healing was slow and the cicatrices in both areas caused contraction. On examination an otherwise essentially normal child presented a contracture of the entire right cheek which caused an ectropion of the right lower eyelid and a turning up of the right upper lip. The right fifth finger was bound by a scar web on the palmar side in right-angled flexion, the tip of the finger nearly touching the palm.

*Treatment.*—The scar on the cheek was excised Nov. 29, 1941, and a thick split graft substituted. A separate operation was contemplated for the relief of the contraction. The scar bridge was excised from the right fifth finger under gas-oxygen-ether anesthesia on Dec. 5, 1941, and a full thickness graft from the abdomen was sutured into the raw surface on the finger. A small aluminum dorsal extension splint was applied to the finger. The entire forearm and hand were placed in a transparent positive pressure chamber of cellulose acetate sealed to the forearm by a glove cuff near the elbow. A slow-speed air pump was employed to maintain a constant pressure of 36 cm. of water by gauge. (See Fig. 4.)

It is interesting and revealing to note that under direct vision through the jacket the graft, except for two small white areas, was all pink at the end of approximately eight hours. These two areas were also pink the next morning (about fourteen hours later). The jacket was comfortable, permitted free turning and movement within it, and remained sealed throughout. Good function resulted.

CASE 4.—G. E. L., Jr., a 24-year-old junior medical student, entered Vanderbilt Hospital on July 5, 1939, for the operative correction of a deformity of his left hand. This followed a burn at the age of 6 when he fell with his hand extended on a hot stove. He was treated with vaseline gauze at the time and no splint was applied. A flexion contracture resulted. At the time of examination there were hard cicatrices at the bases of the second, third, and fourth fingers, as well as on their palmar surfaces. The scars caused marked flexion of the index finger, the tip almost touching the palm, and moderate flexion of the third and fourth fingers. Although there was considerable atrophy of the small muscles of the fingers, the flexor tendons and sheaths did not appear to be damaged. The distal phalanges could be flexed. Except for a limitation of flexion of the right knee, from an old osteomyelitis, the physical was otherwise negative.

*Treatment.*—At operation, July 6, 1939, almost all the dense scar was removed from the second and third fingers and palm by sharp dissection under novocain. The fingers were then rather forcibly extended without material damage to tendon sheaths or arteries. The raw areas were then traced and whole-thickness skin grafts were cut from the right upper arm. The edges of the donor wounds were undermined and sutured. The grafts were sutured at the edges and a few stitches used also to hold them in contact with their bases on the fingers. A posterior extension splint of light aluminum was applied with adhesive to the fingers and hand.

A positive pressure chamber of transparent cellulose acetate was slipped over the hand and forearm. Employing a rubber glove cuff, a hermetic seal was formed near the elbow. By means of a water bottle gauge, air pressure at 42 cm. of water was kept on the skin of the forearm and graft. This was maintained for ninety-six hours, at which time the graft was entirely viable. The patient then had a lamb's wool pressure dressing applied to the graft. The skin of the grafted areas subsequently took nicely and the patient regained excellent function of his finger. On the index finger a small trophic ulcer formed near the nail. This was excised and grafted with two small deep grafts. Healing was prompt and has been stable for four years.

CASE 5.—E. N., a white girl of 4 years, gave a history on admission of an electrical burn to her right hand received two weeks before. This was caused when, following a windstorm, she grasped an electric high tension wire which had fallen in her schoolyard, burning the palmar surfaces of the second, third, fourth, and fifth fingers of the right hand. Granulating wounds were present in the areas described as follows: A large wound was found involving most of the palm of the hand and extending on through the palmar surfaces of all the fingers and the web between the right first and second fingers. With hot soaks of saline solution, followed in a few days by Dakin's solution irrigations, the wounds healed except for small granulating areas on the palmar surfaces of the second and third fingers. Two

months later the patient was readmitted on Nov. 7 with marked flexion contractures of the second, third, fourth, and fifth fingers, most marked at the proximal interphalangeal joints. All except the latter were drawn down to a right angle. The latter was held in flexion to within 15 to 20 degrees of complete extension.

At operation, Nov. 11, 1938, the scars from the four fingers of the right hand were excised from their palmar surfaces. Four whole-thickness grafts were cut by pattern from the anterolateral surface of the right upper thigh. The edges of the wounds at the donor sites were undermined and easily closed with mattress sutures. The grafts were fitted and sutured into the wounds of the fingers. The tendon sheaths were left intact. A small thin aluminum splint shaped to the individual fingers was strapped to the dorsal surfaces of the fingers and to the hand with sterile adhesive to hold the fingers extended. (See Fig. 5.) Without any further dressing the whole hand and forearm were placed in a positive pressure cylinder of cellulose acetate with a cylindrical glove cuff between the upper forearm and the jacket to make it airtight. A pressure of 25 to 30 mm. of water, regulated by water bottles (see Fig. 5), was kept constantly applied.

The following notes are taken directly from the hospital record: "Under direct vision the take of the grafts is evidenced by a progressive change from white to pink observed as follows: The fifth finger graft was definitely pink five and a half hours after operation. A portion of the graft of the third finger was pink ten and a half hours after operation. The grafts were not observed during the night after 11 P.M., but by the next morning (twenty-one hours after operation) the grafts of the second and fourth fingers had become pink for the most part and twenty-five hours after operation they were pink throughout."

In three days' time the grafts were definitely viable as evidenced by their livid pink color. No blistering was present. A little boric acid ointment was applied and lambskin with the wool attached was cut to shape and applied with slight pressure over gauze to the grafts. The splint was left on and bandaged in. The grafts all took nicely. (See Fig. 5*d*.) In twenty days the patient could fully extend and flex the fingers. The patient's hand was examined several weeks after grafting and function of the fingers was found to be normal.

The rubber glove-cuff seal which was employed held the pressure with insignificant leakage. The 30 cm. head of water in the upper bottle only needed restoring at twelve-hour intervals. Ordinary lubricant jelly such as is commonly employed in hospital wards was applied to the upper forearm before application of the jacket to improve the seal.

The hand and forearm were comfortable at all times, and the latter, after many days, showed no pressure ring at the point of contact of the airtight glove-cuff seal.

### CONCLUSIONS

Evidence presented appears to warrant the following conclusions:

1. Extensive burns in addition to causing early primary shock also may produce early circulatory changes and physical and chemical alterations in the blood from plasma loss and surface absorption.

2. The systemic and local treatment in burns should, therefore, be considered an emergency of the first order to be carried out as soon as the patient's condition permits.

3. The patient's general condition should be treated by appropriate measures in each stage following the principles and indications outlined.

4. In the treatment of his wound, avoidance of contamination and prevention of plasma loss and of surface absorption are of paramount importance.

5. In accomplishing these aims from the start, strict asepsis, an efficient cover infrequently changed, and a certain amount of mechanical pressure or pressor drug action on the part are of aid.

6. The transparent wound jackets described are of definite use in carrying out these aims.

7. They are of definite value in preparing the surface for early grafting and for applying regulated pressure to grafts and the tissues underlying them.

## REFERENCES

### *General References*

1. Douglas, B.: Practitioner's Library, George Blumer, Vol. v, Chap. 1, New York, 1934, D. Appleton-Century Company, Inc.
2. Berkow, S.: Am. J. Surg. 11: 315, 1931.
3. Underhill, F. P., Carrington, G. L., Kapsinow, R., and Pack, G. T.: Arch. Int. Med. 32: 31-49, 1933.
4. Willis, A. M.: Tr. South S. A. 194: 84, 110, 237, 655, 1925.
5. Report of Committee on Surgery, National Research Council: Army M. Bull. 6: 24, 1942.
6. See Douglas.<sup>1</sup>
7. Pack, G. T., and Davis, A. H.: Burns, Philadelphia, 1931, J. B. Lippincott Company.
8. Harkins, H. N.: The Treatment of Burns, Baltimore, 1942, Charles C Thomas, Publisher.
9. Marchand, and Schultz: Quoted by Douglas.<sup>1</sup>
10. Ravenna, and Minissian: Quoted by Pack.<sup>7</sup>
11. Robertson, and Boyd: See Douglas.<sup>1</sup>
12. Douglas, B.: J. A. M. A. 81: 1937, 1923.
13. Douglas B.: Compt. rend. Soc. de biol. 92: 267, 1925.
14. Douglas, B.: Thèse, Université de Lyon, Lyon, Fr., 1925, Bose Frères and Riou.
15. Christophe, L.: Presse méd. 46: 1054, 1938.
16. Aldrich, R. H.: New England J. Med. 208: 299, 1933.
17. Firor, W. M.: See Aldrich.<sup>16</sup> (Suggested gentian violet treatment.)
18. Cruickshank, R.: J. Path. & Bact. 41: 367, 1935.
19. See Wilson, W. C., et al.<sup>28</sup>
20. See Douglas.<sup>13, 14</sup>
21. See Douglas.<sup>14</sup>
22. Krogh, A.: Silliman Lectures, Anatomy and Physiology of Capillaries, New Haven, 1922, Yale University Press.
23. Davidson, E. C., and Matthew, C. W.: Arch. Surg. 15: 265, 1927.
24. Menkin, V.: Quoted by Harkins.<sup>8</sup>
25. See Aldrich.<sup>16</sup>
26. Menkin, V.: J. Exper. Med. 64: 485-502, 1936, cited by Harkins.<sup>8</sup>
27. Menkin, V.: J. Exper. Med. 67: 129-144, 1938, cited by Harkins.<sup>8</sup>
28. Wilson, W. C., Jeffrey, J. S., Roxburg, A. N., and Stewart, C. P.: Brit. J. Surg. 25: S26, 1938.
29. Baraduc, Klebs, Tappeiner, and Locke: Quoted by Douglas.<sup>1</sup>
30. See Wilson, W. C., et al.<sup>28</sup>
31. Blalock, A.: Arch. Surg. 22: 610, 1931.
32. Johnson, G. S., and Blalock, A.: Arch. Surg. 23: S55, 1931.
33. See Harkins.<sup>8</sup>
34. Freeman, N. E., Shaw, J. L., and Snyder, J. C.: J. Clin. Investigation 15: 651, 1936.
35. Weiskotten, H. G.: J. A. M. A. 72: 259, 1919.
36. Greenwald, H. M., and Eliasberg, H.: Am. J. M. Sc. 171: 682, 1926.
37. Hartman, F. A., Rose, W. J., and Smith, E. P.: Am. J. Physiol. 78: 47, 1926.
38. Brooks, B., and Blalock, A.: Ann. Surg. 100: 728, 1934.
39. Goodpasture, E., and Douglas, B.: Recent Autopsy Reports.
40. Swingle, W. W., Parkins, W. M., Taylor, A. R., and Hays, H. W.: Am. J. Physiol. 123: 659, 1938.
41. See Wilson, W. C., et al.<sup>28</sup>
42. See Brooks and Blalock.<sup>38</sup>
43. Owens, Neal: Personal communication, August, 1943.



44. See Douglas.<sup>1</sup>
45. See Douglas.<sup>12</sup>
46. See Owens.<sup>43</sup>
47. Bettman, A. G.: J. A. M. A. 108: 1490, 1937.
48. See Report of Committee.<sup>5</sup>
49. See Douglas.<sup>12</sup>
50. See Harkins.<sup>8</sup>
51. Douglas, B.: J. A. M. A. 82: 381, 1934.
52. See Douglas.<sup>14</sup>
53. Underhill, F. P., Kapsinow, R., and Fisk, M. E.: Am. J. Physiol. 95: 315, 1930.
54. See Krogh.<sup>22</sup>
55. See Douglas.<sup>13</sup>
56. See Douglas.<sup>13</sup>
57. McCollum, D. W.: Am. J. Surg. 39: 275, 1938.
58. See Douglas.<sup>13</sup>

*References on Transparent Jacket Method*

59. Douglas, B.: Jour. Tennessee M. A. 29: 160, 1936.
60. Douglas, B.: Am. J. Surg. 43: 2, 1939.
61. Douglas, B.: South. M. J. 32: 12, 1939.
62. Bunyan, J.: Proc. Roy. Soc. Med. 34: 65-70, 1940.
63. Hudson, R. V.: Brit. M. J. 2: 17, 1941.

*General References Continued*

64. Wright, A. D.: Brit. M. J. 2: 996, 1930.
65. Orr, H. Winnett: The Treatment of Osteomyelitis and Other Infected Wounds, Chicago, 1927, R. R. Donnelley and Son.
66. Treuta, R. J.: Treatment of War Injuries and Fractures, New York, 1940, Paul B. Hoeber, Inc.
67. Douglas, B.: Ann. Surg. 91: 659, 1930.
68. Douglas, B.: Surg., Gynec. & Obs. 61: 458, 1935.
69. Douglas, B.: Arch. Surg. 32: 756, 1936.
70. Cope, O., and Rhinelander, F. W.: Ann. Surg. 117: 915, 1943.
71. Cope, O., Nathanson, I. T., Rourke, G. M., and Wilson, H.: Ann. Surg. 117: 937, 1943.
72. Peters, J. P., and Van Slyke, D. D.: Quantitative Clinical Chemistry, vol. 2, Baltimore, 1932, Williams & Wilkins Company.
73. Miller, B. F., and Van Slyke, D. D.: J. Biol. Chem. 114: 583, 1936.

## EARLY TREATMENT OF BURNS

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BURNS, either alone or in combination with other injuries, are a frequent cause of casualties, both for civilians and members of the Armed Forces, during the present war. As most individuals thus injured live, mortality rates do not give a true picture of the economic loss. The price of prolonged hospitalization, suffering, disability, disfigurement, and mental upset is enormous. Members of the medical profession now in the armed services, who in ordinary circumstances would have referred serious cases to those particularly interested in this subject, now must undertake their management alone. This problem would not have been difficult if a burn were an entity like many other conditions. On the contrary, it requires knowledge of the treatment of a peculiar type of large wound. It is made doubly difficult by being a wound which is extremely painful, usually has copious exudate, is accompanied by much edema in adjacent tissues, is easily contaminated, and which cannot be closed immediately unless small. If treated kindly, it will close itself quickly by the natural healing processes, when the injury has been superficial. If deep, delayed closure takes place by healing from the sides of an ulcer with contracture and scar epithelium, or by skin grafting. The early treatment has many controversial aspects about which there is no general agreement.

*The Problem.*—It is not the purpose of this communication to discuss the relative merits of innumerable agents and methods used in local treatment. One method known to be good will be discussed and described. This decision was made because there is need to urge one form of local treatment which is so simple that it can be understood and put into reasonably good practice by those who, having never treated a severe burn previously, are now faced with the possibility at home, and the probability in battle areas, of having to care for many such casualties. The members of the profession who treated large numbers of burns in peacetime were few. Suddenly it has become necessary that many be prepared to do so. The multitude of materials, and the methods for their application, which have been advised (and to which there is constant addition), has served to confuse the uninitiated who are to be the all-important vehicles for carrying early treatment to the patient. This is particularly so in the Armed Services. Those who have special knowledge and facilities should undoubtedly continue with investiga-

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tion of the burn problem in all its aspects. One part of this is the finding of better materials and methods for local therapy.

The subject of burn treatment may be divided into that designed for prevention and that designed for cure. That "prevention is better than cure," is most true when it is applied to burns. Much remains to be done on this aspect of treatment which is not within the scope of this communication. Therapy designed for cure is divided into early, intermediate, and late. The early treatment may be said to have ended when the first week has passed. This time is chosen because then the initial phases of primary and secondary shock have elapsed. The liver and kidneys are beginning to show evidences of recovery from the toxic state.<sup>1</sup> The average time of death in our cases in recent years has been about five days (excluding deaths later than ten days after the accident).<sup>2</sup> This article will discuss early treatment under the heading of local and general therapy. It is not intended that anything original be introduced. The material presented represents opinions formed as the result of experience with many burns in children and adults in civilian and service practice.

*Topical Application.*—The question of local application, being the most controversial, is discussed first. In choosing a material for service use, simplicity must rule. It is better if it is the same for first aid and definitive therapy. Whatever is chosen should be available in large supply, easily packaged for continued sterility and handiness in use, and capable of withstanding wide variations in temperature without change in composition or texture on return to ordinary operating conditions. Its use should be easy for nonmedical personnel and untrained medical personnel. It should not be harmful to already damaged tissue cells. The latter is one of the controversial points. Except in a gross manner, it is difficult to know what materials are injurious when applied directly to the exposed epithelial cell elements remaining in the dermis. The healing processes are undoubtedly affected by the local application, but controls are difficult to arrange, and the assessment of results to the satisfaction of everyone is practically impossible. The presence of infection, maceration, and chemical irritation or necrosis are the most obvious causes of damage to epithelial cells during the course of treatment. They are likely of greatest importance in the order named. The combination with the material used for local application of bactericidals or bacteriostatics would appear to be a sound principle as long as these substances do no direct damage to the remaining dermal epithelial cells, or the course of repair. The latter includes the separation and removal of dead tissue, and the recovering process. The details of how this takes place, and what retards or expedites it, are so little understood that it is useless to wait for decisions on controversial points to determine what should be urged presently for local application. Time will bring the answers to many questions, but that

does not help those whose problems are urgent today. This pertains particularly to those in the Armed Services unskilled in the management of burns. They must be given simple directives to the query, "What is the best method of handling the burned area?" That which constitutes the "best" must at most represent an opinion with which many may not concur. Thus a "good" method as viewed by present-day standards, and one which uses a material for local application which satisfies reasonably well the desirable features mentioned above, is a cream, jelly, or ointment *occlusive pressure dressing method* such as described by Koch,<sup>3</sup> Ackman and Wilson,<sup>4</sup> and others.

*Consideration of a Cream, Jelly, or Ointment.*—The perfect material for local application has yet to be found. There are so many qualities that are expected of it that the likelihood of combining them in one material is remote. The search has received most decided impetus since the commencement of the war. The comparison of materials is difficult owing to the varied depths of burns, unknown factors affecting healing, the myriad permutations and combinations of differences in age, sex, race, nutrition, hormonal activity, etc., which make one individual different from another. Many substances have had extravagant claims made on their behalf, such as vitamins and hormones in mixtures. There is lacking anything approaching conclusive evidence of their value. The "kindliness" with which some donor areas heal after removal of "calibrated" skin grafts, when compared to other parts of the same area treated differently, is fair proof of the undesirable qualities of some forms of surface application.

The advantages of an ointment, cream, or jelly are many. Those of particular importance are listed.

1. It is easy to apply by medical and nonmedical personnel.
2. It needs no elaborate paraphernalia in its employment.
3. It can be packaged in a sterile fashion in suitable containers.
4. It can be combined with gauze mesh in the original packaging. This eliminates one maneuver in the primary dressing.
5. Depending on the medicaments in it, it can be made available in large supply.
6. Ointments can be made, which after wide variations in temperature, return to the original composition and texture.<sup>5</sup>
7. It can be applied quickly—time does not have to be allowed for drying as in the case of escharotics and plastic materials.
8. A repeat application is not necessary. The first-aid treatment can, if circumstances demand, become the definitive treatment.
9. Nursing care necessary is at a minimum.

All of these points are most advantageous in service practice. Indeed, they are in certain situations "all important."

Ointments vary much and that which is an advantage in one is a disadvantage in another. A water miscible base would appear to have

some advantages, if the material for local application were to be changed to another whose action was disturbed by the presence of oil. If the original material were continued to the skin grafting stage it would be necessary to switch from the oil containing ointment. However, this is a minor matter as the patient is by that time probably in a hospital where such changes are not difficult. Obviously, there is much to be learned concerning the bases from which ointments are made and their effects on the repair processes. That infection and maceration are harmful has already been stated. Skin surfaces may have epithelial cells injured by the steeping which takes place when a dressing is used which prevents the escape of moisture. This is prone to take place under vaseline, but less so if it is combined with other medicaments. Thus, borated vaseline seems less macerating. Water miscible creams and jellies are less likely to cause it.

*Contamination and Infection.*—The problem of infection is best managed by prevention of initial contamination rather than by bringing it under control later. This prevention may be impossible due to circumstances, such as the nature of the injury, and the time between the accident and satisfactory therapy. Infection means the invasion of the tissues of the body by living pathogenic organisms in such a way as to favor their growth and permit their toxins to injure. Thus, there is often contamination without the condition progressing to an infection of any significance, despite the fact that this large open wound has some partially cooked tissue as its base, or later has granulation tissue. Infection in our experience has not been a great producer of morbidity or mortality. That contamination can be completely removed or infection can be controlled by surface applications of medicament is controversial. The type of medicament, the amount and type of contamination, and the quantity of necrotic tissue present would appear to be important factors. Sulfonamides have been of help. Other bacteriostatics and bactericidals of more ancient use are also of value. There has been some tendency to put them aside. That sulfonamides represent only a phase in the search for better materials is forecast by reports of penicillin as published.<sup>6</sup> While sulfonamides are far from ideal, their known value at present is sufficient to cause their inclusion in any ointment which is chosen, until other compounds have been well tried and found more satisfactory by those who have proper skill and facilities. The adsorption from a large open wound such as a burn of second degree is so rapid that care must be taken not to employ a very soluble sulfonamide directly on the surface, or to incorporate it in an ointment from which it is not too quickly removed. Under such circumstances the toxic effect of the drug is an added insult to an already sick patient. Local concentration can be maintained for many days if sulfathiazole is incorporated as recommended by Ackman and Wilson.<sup>7</sup>

*The Application.*—When an ointment or cream is put on a burned surface it should spread easily and adhere to that surface. This is a quality not possessed by some unguents. This factor can be circumvented by applying them directly to the gauze, and thence to the body surface. It is even better if the material is parceled in such a fashion that this maneuver is not necessary, the ointment being impregnated in gauze and packed so that a small part may be used without gross contamination of the whole bundle.

The gauze may be of wide or close mesh. The former is preferable as it carries much ointment and allows drainage into supporting dressings. When granulation tissue forms the surface, the gauze should be finer as the granulations tend to grow through the coarse variety if it remains on for some time. The chief difference between this and *tulle gras* is in the material (ointment or cream or jelly) used with the gauze.

The local application should overlap considerably the limits of the burned area. It is padded by sterile fluffed gauze or machinist's waste. Firm bandaging with pressure reinforced by adhesive plaster fixes the dressing. The type of bandage used by us has been flannelette cut on the bias. This has some stretch so that pressure can be applied and maintained for some time. Elastic bandages or elastic adhesive rolls are satisfactory. Enough padding is used to absorb considerable exudate. More is necessary with superficial than with deep burns as the latter do not "weep" so much. The pressure is designed to check the "bleeding" of the plasma into the tissues adjacent to the surface lesion. Thus the local edema is largely controlled. If this pressure dressing is removed at any time during the first few days after the accident, swelling will take place.

The padding, and bandaging, and fixing of the dressing represent the most difficult part of this form of treatment. The supply factor (of padding and suitable bandages) is a disadvantage in service practice, but is not a great problem in civil establishments. It requires practice for medical personnel to put a satisfactory dressing of this type on hands or face where many of the burns occur. Nonmedical personnel would need much instruction and practice. Cleansing and débridement, local application, and the pressure dressing being three distinct steps in the therapy of the local lesion, the first and last may have to be neglected, from force of circumstance. The pressure bandage should be applied as soon as possible, and thus nonmedical personnel should be taught its use. Cleansing and débridement are closely similar to a surgical operation in that they need sterile supplies and sterile technique as well as a plan of action to produce the appropriate effect. Thus, first-aid therapy includes an ointment or cream in gauze application, next to the burned surface, overlaid by some padding, the whole being fixed by a pressure bandage and adhesive plaster. The first-aid therapy

should be continued as the definitive treatment if much time has elapsed between the two, no débridement being considered advisable.

Too much emphasis cannot be placed on the prevention of contamination. Treating the burn as a large open wound if circumstances permit is most important. All the usual surgical precautions concerning sterility are urged—sterile gowns, gloves, drapes, instruments, and the masking of the patient and all who are near. If circumstances permit segregation of patients, burns should be in a ward apart from patients with infections. The local application, if and when it represents the definitive local treatment, should not be removed for at least a week unless circumstances warrant a change. The constant change of dressings does no good, and often does harm.

*Cleansing and Débridement.*—Controversy arises from the fact that the value of a débridement in this type of wound is not agreed upon by all. Certainly in many cases treated by us without débridement the results have been generally satisfactory. However, it is our opinion that débridement should not be abandoned by the casual treater of burns, until more evidence accumulates to support this contention. If there is no supply of sterile water, soap, or detergents, no method of controlling pain during the procedure, or much time has elapsed between the accident and the first treatment, the circumstances might justify its omission. This step in the treatment has been accomplished in our work by flooding the part with sterile water or saline solution. Cultures of the soap solution distributed by the pharmacy at our hospital resulted in the growth of a variety of organisms. Thus, a sterile solution of a soft soap is used. Benzine may be used at this stage to remove oil or grease. The débridement consists in removal of any portion of the skin that is loose or raised in blebs. This is done rapidly, using wet gauze as a "wipe." In the average case (less than 10 per cent of the body surface affected) it should not take more than two or three minutes. It may be necessary to scrub with a brush a burned area into which foreign particles have been driven. There must be some definite reason present for such therapy because it is associated with considerable direct trauma to the surface. The area is dabbed dry with a towel and the local application applied.

#### GENERAL THERAPY

*Control of Pain.*—While control of pain is primary in the mind of the patient, it cannot be carried out satisfactorily if there are no medical personnel present. Thus, the question of local application was dealt with first. Pain is controlled by intravenous morphine;  $\frac{1}{6}$  gr. intravenously and a similar amount hypodermically by withdrawal of the needle is an average initial dose for adults. The intravenous portion is administered slowly. If medical personnel are not present and morphine is available it may be given ( $\frac{1}{4}$  gr.) by mouth but the delay in action is

so great, that if medical personnel can be reached within one-half hour it is better to give nothing. A general anesthetic is rarely necessary. Many burns are associated with damage to the respiratory tract by fumes or superheated air. Chest complications may occur rapidly. A general anesthetic is a complicating factor and should be particularly avoided in this type of case.

*General Supportive Measures.*—While primary or neurogenic shock may be seen, it has not been a factor in our cases. Lying down, with freedom from disturbance and maintenance of body warmth, should bring it under control quickly.

Happily, the subject of this article does not permit a discussion of what is meant by secondary shock or its signs and symptoms. Its treatment in burns of moderate or severe degree should start long before it can be seen clinically by ordinary observation. That is the first factor to recognize. The second is that it should be adequate. Whole blood, concentrated serum, normal serum, and plasma have been used by us in this phase. The viscosity of the concentrated serum made it difficult to employ. While some reactions (chills and fever), related by us to the administration of these materials, have been noted with normal pooled serum and pooled plasma, they have both been satisfactory within the limits of this type of therapy. Whole blood was used much, a number of years ago, and was also of undoubted value. As the red blood cells do not appear to be necessary or altogether desirable at this stage, plasma or serum are recommended. The amount of plasma necessary to control the hemoconcentration as evidenced by whatever estimation that is being used (hemoglobin, specific gravity, etc.) is large and bears some relation to the size of the burn. Ideally, to restore the original blood volume is the aim. From a practical point of view this should remain the aim if circumstances and supplies exist. Clinical improvement in patients with much smaller doses is remarkable, even without laboratory evidence of control of hemoconcentration.

Experience has taught that small burns (under 5 per cent) are not to be feared as far as mortality due to secondary shock is concerned. These, despite a degree of hemoconcentration, may be neglected as far as the attempt to maintain blood volume is concerned. Burns of over 40 per cent of the surface may be considered progressively more serious according to size. The necessity to provide agents to maintain blood volume also becomes increasingly urgent. As the flow of plasma into the tissues, and possibly from the surface, starts immediately, the intravenous plasma or serum should be started at once, without waiting for signs of distress on the part of the patient as evidenced by ordinary observation. Thus, the quantity of plasma is given empirically, additions being made as tests reveal the necessity. The majority of our patients having been children, we have worked on the basis of 3 c.c. of plasma per 1 per cent rise in hemoglobin per ten pounds of body weight.



If later the serum protein drop is significant or the hemoconcentration is not controlled, more plasma may be given. It is not our opinion that the apparently ideal quantity (i.e., the quantity necessary to completely restore the original blood volume as estimated by blood examinations, hemoglobin, hematocrit, etc.) must necessarily be given. Indeed, the use of such quantities might be criticized as wasteful of material which is expensive, and which on administration is not entirely free from reactions of a disturbing character. Whether plasma serum or whole blood should be given, and in what doses, for intermediate or late therapy, need not be discussed in this communication.

It is only fair to state that while quantities given at the present time might on occasions seem unnecessarily large, the error occurs more often in the opposite direction. Many rules have been given by which the quantity may be estimated, such as by Harkins,<sup>8</sup> Black,<sup>9</sup> and Elkington, Wolff, and Lee.<sup>10</sup> This type of supportive treatment is commenced immediately in a burn of over 10 per cent in an adult. In smaller burns our policy has been to be guided by the clinical data as it developed. The intravenous apparatus in our cases has been kept running between the periods when the serum or plasma was being administered, with 5 per cent glucose or a mixture of glucose and normal saline solution. It is most important that fluid output (urine and vomitus) be carefully measured. In an adult a twenty-four hour urinary output of at least 1,000 c.c. is desired. For some hours after the accident, even in severe burns, the patient may take fluids well by mouth.

Concerning other supportive general therapy, the use of cortin has seemed in our experience to be of value. There is little beyond impression to support this, however. Its employment can safely be left with those conducting investigation. Its expense and scarcity are too great for routine use. Oxygen in high concentrations should be given to patients showing cyanosis. A slowed peripheral circulation, and cyanosis is present in most cases of moderate or severe degree. There has been a tendency on our part to neglect this aspect of treatment.

*Early Complications.*—Mild jaundice is noticed occasionally. Beyond the usual supportive measures with glucose solution intravenously, no specific measures aimed at the cause of the lesion have been used by us. Vomitus containing changed blood is common. Massive hemorrhage may happen from erosion of the lower part of the esophagus or from stomach or duodenal ulcer; this is uncommon. Whole blood replacement is given. Uremia and anuria may occur and beyond the measures usually taken for these conditions nothing further has been employed. Chest complications due to associated respiratory tract damage must be dealt with as they arise. Oxygen is valuable. Two cases of mediastinal emphysema have been seen. In one no treatment was instituted and recovery took place. In the other case there was steady progression of the emphysema up over the neck and chest. A tracheotomy was per-

formed with temporary improvement. The patient later died, and the value of the tracheotomy was problematical. Pneumonia has been seen in a number of cases. Acute pulmonary edema has also been encountered. The giving of the large quantities of intravenous fluids (plasma and electrolytes) in such cases has been discontinued.

### CONCLUSIONS

1. An attempt has been made to indicate one good method of early treatment so that the uninitiated faced with the likelihood of having to treat cases may be prepared both with the knowledge and the equipment to use one method well.

2. Emphasis has been placed on using the same materials and equipment for both first-aid and definitive treatment.

3. The topical application was discussed and the reasons given for the choice, with emphasis on simplicity.

4. The general measures associated with relief of pain and supportive measures were mentioned briefly. These have been discussed so much in recent literature that it appeared useless to go into detail.

5. The early complications were mentioned briefly.

### REFERENCES

1. Erb, I. H., Morgan, Ethel M., and Farmer, A. W.: *The Pathology of Burns*. Ann. Surg. 117: 234-255, 1943.
2. Farmer, A. W.: *Experience With Burns*, Am. J. Surg. 59: 195-209, 1943.
3. Koch, L. S.: *Treatment of Burns*, Bull. Am. Coll. Surgeons 27: 106-108, 1942.
4. Ackman, D., and Wilson, G.: *Sulphathiazole Emulsion*, Canad. M. A. J. 46: 209-214, 1942.
5. R. C. A. F.: *Memo on sulphathiazole emulsion (Montreal formula)*.
6. Proc. Staff Meet., Mayo Clin. 17: 1942.
7. Ackman, D., and Wilson, G.: *Further Experience With Sulfathiazole Emulsion*, Canad. M. A. J. 47: 1-7, 1942.
8. Harkins, H.: *The Treatment of Burns*, Springfield, Ill., 1942, Charles C Thomas, Publisher.
9. Black, D. A. K.: *Treatment of Burn Shock With Plasma and Serum*, Brit. M. J. 2: 693-697, 1940.
10. Elkington, J. K., Wolff, W. A., and Lec, W. E.: *Plasma Transfusion in the Treatment of Fluid Shift in Severe Burns*, Ann. Surg. 112: 150-157, 1940.

## REPAIR OF THE BURNED HAND

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**C**RIPPLING burns of the hand challenge the plastic and reconstructive surgeon. Together with his brain, man's hand, that beautifully engineered mechanism peculiar to genus homo, has been responsible for his commanding position in the universe. So delicately balanced and so interrelated in action are the components of its parts that damage to one part profoundly affects the functions of the other parts. The variety of movements of the wrist and of the thumb together with the fingers is astounding. This brief discussion aims to analyze some of the crippling injuries of the hand due to burns and to present our solutions for restoration of function.

The controversial discussion of treatments of fresh burns is purposely omitted and attention is focused on repair after the acute stage is past.

Because of its exposed position, the hand is frequently burned. A rapid review of the anatomic structure of the hand is a necessity for planning any reconstruction surgery, so that a proper evaluation of the tissue destruction may be had, and a proper selection of a plan of repair may be arrived at.

The dorsum of the hand and fingers is more frequently burned than is the palm. Here the skin is rather thin, soft, and pliable and there is very little subcutaneous fat in the superficial fascia. The deep fascia over the wrist is thickened to form the posterior annular ligament, which protects the tendons passing beneath, and which deep fascia then extends over the dorsum of the hand and fingers as a thin and delicate membrane. Here the deep fascia covers the extensor tendons but provides little protection for them where the burn is at all deep. Over the dorsum of the fingers there is little subcutaneous tissue and this, with the skin, forms only moderate protection to the tendons and joint capsules.

The volar surface of the wrist beneath the skin is protected by a thickened deep fascia, constituting the anterior annular ligament, below which pass the flexor tendons. The skin of the palm is heavier and characterized by a horny thickened epithelial layer. The superficial fascia of the palm is dense and thin and closely connects the skin of the palm with the deep fascia. The deep fascia in its central portion is dense and thick and protects the underlying vessels, nerves, and tendons from injury in all except the deepest burns. Over the thenar and hypothenar eminences the deep fascia is very thin. The skin of the volar surface of the fingers is much the same as that of the palm, but the fatty

pads over each phalanx are thicker and with the denser tendon sheaths offer considerable protection against injury.

So it may be seen that in the palm the median and ulnar nerves with sensory branches to the fingers and motor branches to the intrinsic muscles of the hand, the superficial and deep flexor tendons and the arterial supply are well protected against quite deep burns.

The conjoined tendons of the lumbricales and interossei should be especially noted. Although these muscles are well protected in the palm their conjoined tendons pass along the lateral borders of the fingers and insert into the extensor tendons near the middle joints. Their function is important as they extend the middle and distal phalanges of the fingers, and their more exposed position permits frequent damage in many burns.

Burns of the hand vary in degree, of course. First degree burns may cause blisters and may result in sensitiveness and redness for months. Persistent furunculosis is often annoying. However, no surgical repair is needed.

Second degree burns those through the skin and into the superficial fascia, cause dismaying deformities. The dorsum of the hand is more frequently burned than the palm, as probably the hand closes instinctively when it is threatened by fire.

As in burns of any part of the body, the incontrovertible dictum of lifting of denuded areas at the earliest moment possible is especially indicated for the hand. Granulation tissue is the parent of scar tissue, and the more granulation tissue that is allowed to proliferate the more scar tissue will result with increased contractures, lessened blood supply, and later dysfunction of the part.

The surgeon sees a great number of burns of the dorsum of the hand which are betwixt and between, in other words, burns which involve a part of the epidermis, the specialized cells of the skin. After the acute stage of the burn and when the slough has cleared away, in a few days there appears a great multitude of tiny epithelial islands in the granulation tissue. These are the outgrowth of epithelial cells from the glandular structures such as hair follicles and the ducts of sudoriferous glands and sweat pores which penetrate deeply and parts of which have survived the burn. The islands spread rapidly, coalesce and form a patina, a delicate and lush whorl which thickens with increasing layers of epithelial cells. These burns will not require skin grafts. A period of toughening of the new epithelium and of restoration of function of the fingers must follow. The part must be guarded against blows, which easily cause hematomata under the new protecting cells, and scrapes, which with very little resistance slide under the fragile cells.

Although healing may be rapid and satisfactory with good return of function, this function is often almost and appearance marred by the so-called keloid, which makes its appearance in from one to

three months after healing has occurred. This hyperplasia of fibroblastic tissue follows a high percentage of burns. One can hardly avoid considering it as a form of new growth as it differs from ordinary hyperplasia of scar tissue in that the fibroblasts follow out along the blood vessels and the growth spreads considerably further than the original tissue destruction. Wherever the true dermis is injured, keloid may occur, as well as in deeper burns. If allowed to progress unhindered the fibrous tissue piles up, often to astounding thickness, and later the aging cells contract, and with the hard thick scar, destroy or limit function. The ugly red gnarled surface is a deformity, and the intolerable itching and burning of the keloid area, especially in hot or cold weather, yields to no surface medication. If taken early, keloid can be inhibited or softened and flattened by roentgen ray therapy. We prefer the use of smaller divided doses at frequent intervals. Without treatment keloids usually pale out, soften, and flatten in from two to four years. Although faster than this, roentgen ray therapy is still slow, and the other alternative is reconstruction surgery, which is rapid. Complete excision of the offending scar with replacement by normal tissue serves both function and appearance. In other words, burn scars of this type and degree where extensor tendons and sheaths are intact can be quickly corrected.

Deeper third degree burns down through the fascia and tendons, even to the metacarpals, present a more difficult problem. Grafting with thinly cut skin should be done early to obtain an area free from infection before repair is attempted. This advice holds true in all but exceptional cases.

The palm of the hand presents the same problems as does the dorsum with some differences due to structure. The thicker palmar skin gives somewhat more protection, but the thinness of the superficial layer quickly exposes the deep fascia, once the full thickness of the skin is burned through. While the deep fascia is indeed thick and a protection to the tendons in the middle of the palm, that part of the deep fascia over the thenar and hypothenar eminences is thin and easily destroyed so that even the mild infection of the granulating stage burns down around the heavy central portion and attacks the tendons beneath, freezing the flexor tendons within them. When keloid follows scarring of the palm contractions are more pronounced and disabling than on the dorsum, repair is more difficult, and contractions are prone to recur.

Third degree burns down through the deep fascia and flexor tendons present a seemingly hopeless picture. Reconstruction of functioning flexor tendons is a far more formidable task than the restoring of extensor tendons.

Burns of fingers and thumb present special problems. On the dorsum second degree burns, especially those complicated with keloid,

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This rapid review of the anatomy of the hand with a survey of the pathologic distortions of that anatomy due to burns brings this discussion to the process of reversal of these distortions, as far as is possible, by reconstructive surgery. A perfect restoration is, of course, impossible but a return of function, contour, and appearance to a major degree is attainable.

The error into which the surgeon most frequently falls in planning a repair of a devastated hand is an underestimation of tissue loss. When scars are allowed to resume their normal position, the amount of tissue needed to fill the defect is often surprising. Indeed, too often is a previously prepared flap dismayingly short of the mark and the results of the repair are disappointing.

To replace the destroyed tissue the surgeon possesses a variety of materials. Free skin grafts of various types, transposed flaps, and the tubed pedicle flap of Gillies are his major armamentarium. Davis grafts should be used almost never. Thiersch grafts are of little value for permanent repair because of a tendency to contract, but they are invaluable for quick healing of burns so that reconstruction may be started early. The split skin graft of Blair has a wider application, as it consists of epithelium and part of the corium, thereby providing a covering with many of the characteristics of full thickness skin. We are enthusiastic concerning the value of skin grafts cut with the Padgett dermatome. The even thickness of the graft gives a much better final result than any graft that we have been able to cut free hand. The machine enables the operator to choose the depth of skin required and the ability to take at least two-thirds of the corium. This insures a soft resultant graft with almost all the characteristics of normal skin, yet with a certainty of take that one could not hope for with a full thickness graft.

The following cases of deformity of the hand due to burns illustrate some of the common problems of this class and show the procedures used to repair the damage.

Fig. 1, *A* and *B*, shows both hands of a patient severely burned in a gasoline explosion, and Fig. 1*C* indicates the limits of flexion possible in one hand five months after the injury, when the patient came under our care. Since the scarred keloid areas could be moved over the deep fascia with the examining finger it was evident that skin grafts without subcutaneous fat could be used for repair. The left hand was repaired first. The scar was dissected off, under nitrous oxide and oxygen anesthesia, and a blood pressure cuff was used to obtain a bloodless field. When the pressure was removed bleeding points were tied with Lukens silk No. 00. The dissection cleared the entire area of the dorsum of the hand from just distal to the wrist to the middle joints of the fingers. A skin graft 0.016 inch thick, large enough to cover the defect in one piece, was taken from the abdomen with the Padgett dermatome. The

skin graft was sutured in place with 6-0 Dermalon suture and then splinted with gauze soaked in saline solution and marine sponges. Dressings were removed on the eighth postoperative day. A similar procedure was carried out on the right hand four weeks later. Fig. 1D shows the result three months later the last operation, and Fig. 1E indicates voluntary flexion in both hands.

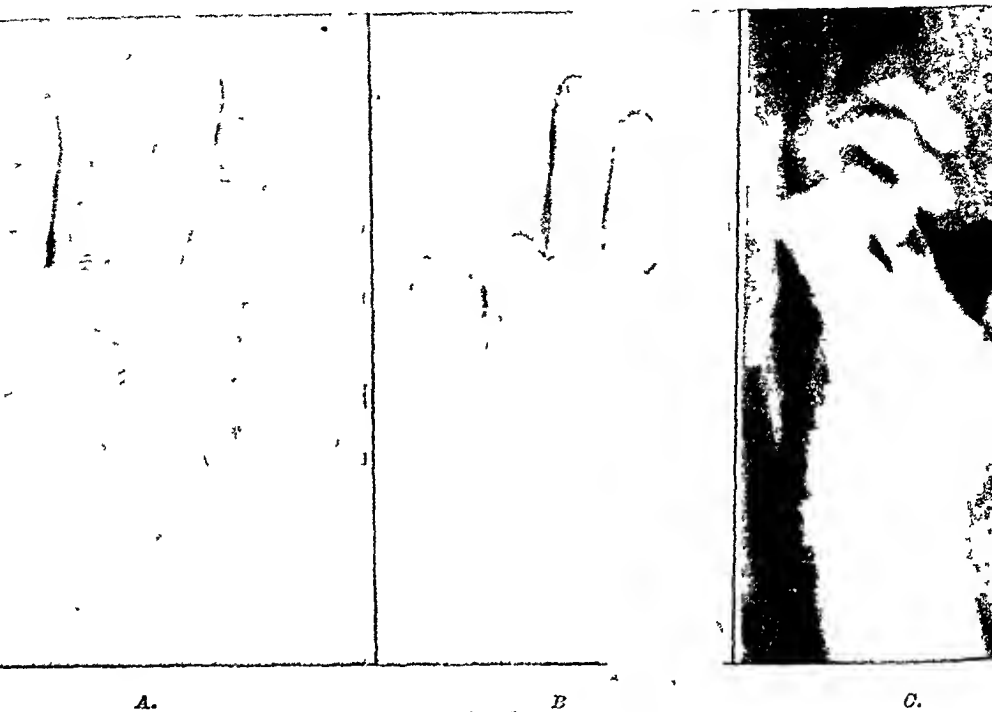
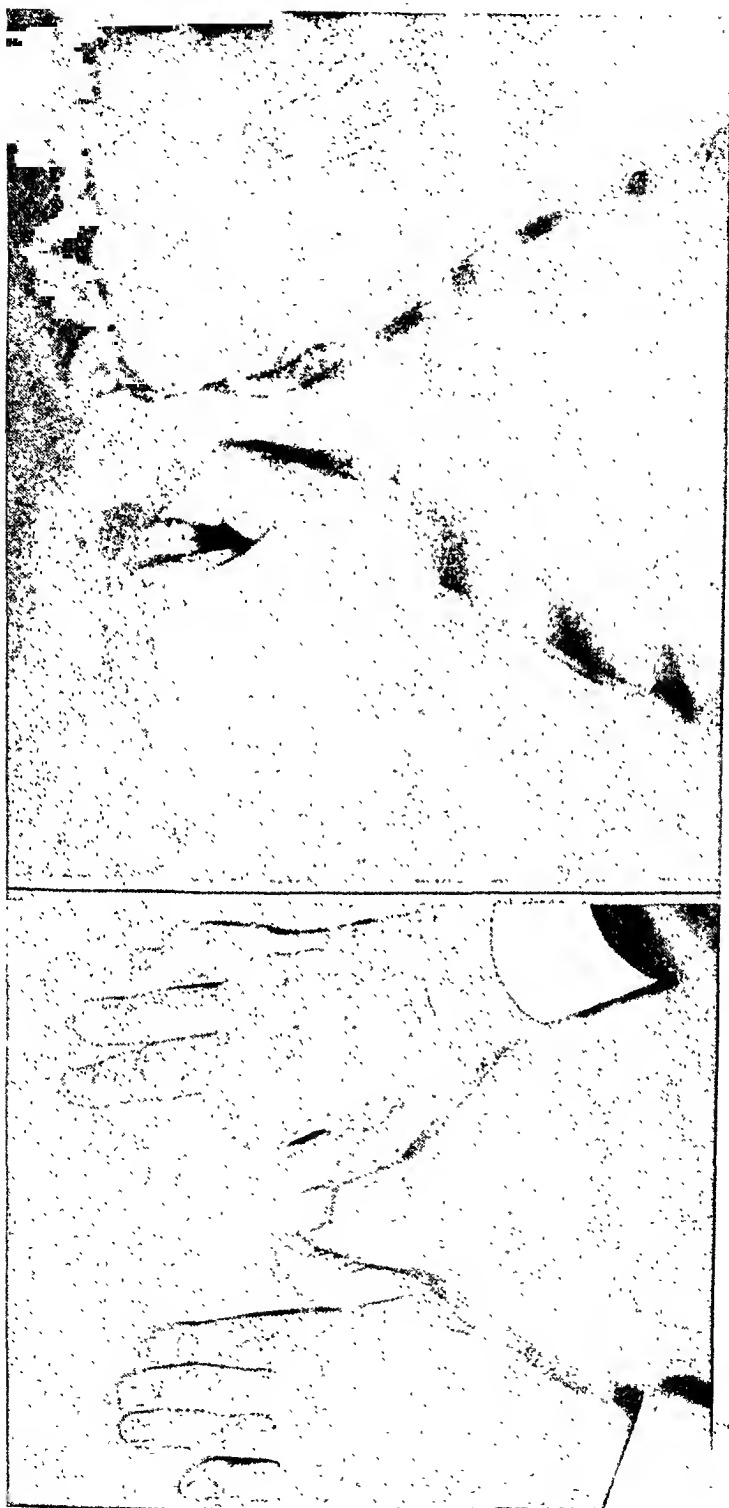


Fig. 1

Fig. 2, A, B and C, shows the hands of another patient, in Case 2, with similar burns and similar resulting keloid scars. Note especially in Fig. 2B the heavy keloid scar limiting abduction of the thumb. Fig. 2D shows the result of the grating of skin by the same method as that used in Case 1. The grafts were also 0.016 inch thick. Fig. 2E shows the amount of abduction of thumb ten days after the scar of the web of the thumb was excised and a transposed flap of skin and subcutaneous fat was swung from the region of the radial side of the base of the index finger into the defect. This method of relieving such contractures is, in our opinion, superior to free skin grafts, as there is little tendency for the flap to contract.

Case 3 illustrates a rather bold procedure which has been previously reported by us.<sup>1</sup> Fig. 3A shows the heavy keloid scar of the dorsum of the hand and all the fingers which froze function. Fig. 3B shows a seven-pedicle flap on the abdomen to replace the entire area of scar. At the same time that the hand was placed under the flap the wound of the abdominal wall was grafted with split skin grafts and Fig. 3C





D.

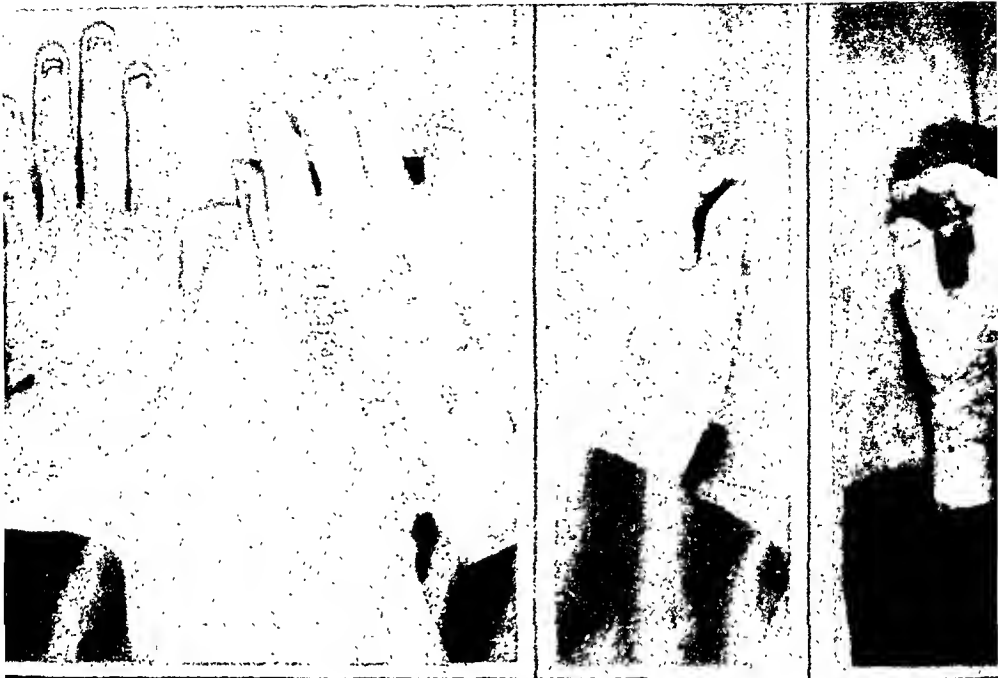
E.

FIG. 1.

A.

B.

C.



D.

E.

Fig. 2.

illustrates the healed area on the abdomen shortly after the pedicles were cut to free the hand. These pedicles were cut only one or two at a time, beginning two weeks after placement and finishing eight days later. The possibilities for extensive reconstruction of the hand are apparent, and the multipedicle flaps have the added advantage of many paths of return for the venous circulation. Venous stagnation is one of the surgeon's difficult problems in reconstruction employing flaps. Fig. 3, *D* and *E*, indicates the final result. Function was excellent and as the subcutaneous fat had been cut very thin there was no bulging of the graft.



A

Fig. 3.

B.

Case 4 illustrates a very heavy keloid scar which has locked the thumb (Fig. 4A). Fig. 4B shows the result soon after replacing the scar with a pedicled flap from the abdomen. Fig. 4C reveals the final result and the degree of flexion, rotation, and adduction possible in the thumb. This method is a better selection than is the use of a free graft for this particular problem.

The young lady in Case 5 had a number of moles on her hands. Too enthusiastic roentgen ray therapy resulted in this characteristic pathology which can be seen in Fig. 5, A and B. This devitalized skin is a potential source of malignancy. Thorough removal and replacement with normal skin and subcutaneous tissue by means of abdominal flaps insured against such future development.<sup>1</sup>



D.



D.

Fig. 3.



C.



C

B

FIG 4

A



C.

FIG. 5.

B.

A.



C

B

A.

FIG 6

The patient in Case 6 suffered very severe burns from a flareback of a furnace which he was tending. Among the worst of his burns was that of a hand, with destruction of the soft tissue of the dorsum down to the metacarpals. All tendons were destroyed. After healing had been obtained by Thiersch graft (Fig. 6A), reconstruction was accomplished with a double-pedicle abdominal flap to provide skin for covering and subcutaneous fat in which to graft extensor tendons (Fig. 6B). The double-pedicle flap assured an excellent arterial supply of blood and also a good venous outflow. The pedicles were severed after three weeks and the final result is shown in Fig. 6C. Unfortunately, this was final, as the patient died of a brain tumor three and one-half months later, before tendons could be grafted.<sup>1</sup>



Fig. 7.

Case 7 is that of a severe burn of the hand and fingers with contraction of keloid scar between the distal half of the palm and the bases of the fingers. A similar method of repair as that used in Case 6 was employed, as the burn was deep, even through the palmar fascia. A worth-while functioning hand was obtained.

A burn scar of the volar surface of the finger is disabling and most inconvenient when contracted as that in Case 8 (Fig. 8A). The scar was dissected out and the resulting raw surface was grafted with a split skin graft of the Blair type, which was splinted with dental modeling



wax. Excellent extension was obtained. At present we would select by preference a graft cut with the Padgett dermatome about 0.022 inch thick.

While employed in a laundry, the patient in Case 9 caught her hand in a hot mangle. Eleven minutes passed before the hand could be released so that the fingers and distal half of the palm were quite thoroughly cooked. When first seen by us the hand was healed with the fingers a fused mass of scar (Fig. 9A). Restoring any function to the fingers or even saving them appeared to be a rather hopeless task, but it was undertaken at the insistence of the patient, but little was promised. At the first stage of operation the fingers were dissected out and found



A.

Fig. 8.

B.

to consist of little more than bone and ligaments, fortunately with good skin on the dorsum of each up to the middle joints. The next step was the preparation of a tubed pedicle on the abdomen. After healing, one end was cut off and applied to the index finger (Fig. 9B). This was cut off at appropriate length after three weeks. Another tubed pedicle was then prepared on the abdomen and, when healing was complete, one end was lifted and sutured into the defect left after removal of the scar from the distal half of the palm. After three weeks the abdominal end of the pedicle was cut free and swung onto the middle finger (Fig. 9C). Six weeks later the pedicle was cut free at its palmar base and the remainder transferred to the ring finger, the circulation

coming from the continuation of the pedicle on the middle finger. After three weeks the pedicle was severed and the tips fashioned. The final stage employed a small abdominal tubed pedicle applied to the little finger. The result is shown in Fig. 9D, and the procedure was most worth while, as the fingers could be flexed almost to the base of the

A.

B



C

D

Fig. 9.

palm and, with the excellently functioning thumb, constituted a useful hand.<sup>1</sup>

After reconstruction has been completed, our task is still unfinished as the patient requires our aid in restoring function. Joint motion is limited in most cases. After many years of experience with the heat and massage treatments of physiotherapy we have discarded them entirely for injured hands. The finger joints react badly to any forced manipulation and we have adopted simple elastic traction to take its place. The patient takes the rubber bands home with him and applies them himself. We recommend off and on periods varying with the problem presented. The patient will never damage the joints with excessive manipulation. After each removal of the bands we instruct the patient to massage the joints, never rubbing the finger over the skin, but deep massage moving the skin with the massaging finger. The middle and distal joints can be rolled between the thumb and finger. Exercise should be encouraged. The results are often surprising. The application of the rubber bands is illustrated in Fig. 10A for the distal joints, Fig. 10, B and C, for the middle joints, and Fig. 10, D and E, for the metacarpophalangeal joints. Multiple rubber bands can be used in combinations.

A condition occasionally arises following burns which is also frequently seen associated with crushing or lacerating injuries of the hands. An area of irritation along the course of a nerve or blood vessel sets up a series of impulses resulting in an abnormal vascular response.

The patient presents a characteristic picture. The hand is cyanotic, clammy, and moist. It is held in a position of semiflexion and the patient resents any attempt at manipulation. There is atrophy of the soft tissues with swelling about the joints of the fingers. The skin is smooth, shiny, and delicate and has lost most of the natural skin folds and markings, which is most noticeable on the dorsum. The patient complains of pain of a vague aching or burning nature, which is almost continuous day and night and is aggravated by cold weather. The pain often radiates to the wrist, elbow, or shoulder. There may be paresthesia, anesthesia, or hyperesthesia of the fingers or hand. The grip is weak and the hand is almost useless. These patients are often classified as hysterical, neurotic, or malingerers, although most of them are very sincere in wishing to be rid of their symptoms. A closer analysis shows hypoaesthesia to pinprick which may be almost complete, involving one or two fingers, or the entire hand in a glove distribution. It is the bizarre pattern of nerve findings which masks the true organic nature of the syndrome, and which accounts for the repeated diagnosis of compensation neurosis. Along with atrophy of the skin and soft tissue, there is shortening of the capsular ligaments of the joints so that the

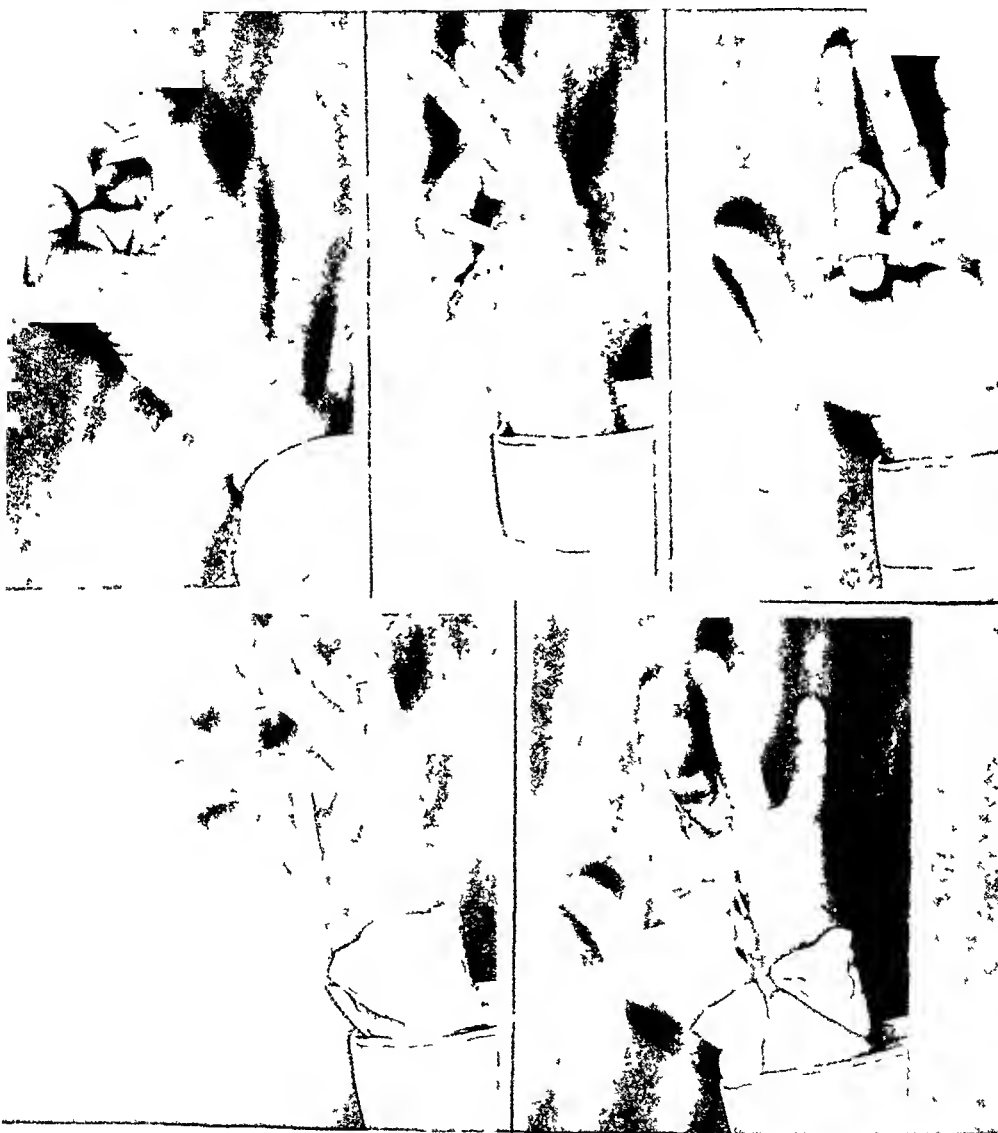
fingers and wrist become stiff, and attempts at motion are painful. This in turn leads to further atrophy of disuse.

The mechanism of the lesion is not yet known, although it has been closely studied by Leriche and others. There are two factors working

A.

B

C



E.

Fig. 10.

E

in contradiction to each other. The original pain, arising from a damaged nerve or blood vessel, evokes a vasoconstrictor response, along with other evidence of sympathetic hyperactivity such as local sweating. The vasoconstriction increases the pain and adds the quality of aching

and diffuse radiation. Any factor which tends to increase the vasoconstriction, such as cold weather, likewise increases the aching, cyanosis, hypoaesthesia, and stiffness in the hand.

Opposed to this is a reflex, compensatory increased blood flow to the entire upper extremity, which gives the pain the quality of paresthesia, burning, and tingling. In hot weather, when the vasodilatation factor is at its height, these latter symptoms are the most annoying. The studies of Miller and deTakats show increased blood flow as a constant finding, and furthermore show that after cervical sympathectomy the blood flow is increased even more. As the vasoconstrictor effect of the sympathetics is now abolished, the pain disappears and the hand approaches normal.

#### TREATMENT

1. Early diagnosis is of prime importance, as the soft tissue atrophy may lead to irreparable damage, especially in regard to stiffening of the joints.

2. Interrupting the vicious cycle of vasoconstriction is brought about by injections of 1 per cent novocain around the ulnar and radial nerves and arteries at the wrist. This is the most effective step of the treatment, and should be done twice a week at first, then at longer intervals, as indicated. The immediate effect of the injection of novocain is remarkable. The hand which was pale and cyanotic becomes flushed and warm, the sweating stops, the pain is eased, and the grip may be increased from 20 kg. to as much as 50 kg. within ten minutes. The joints are more flexible and are not so tender. There may be complete anesthesia for an hour or two, after which sensation returns, but areas which were anesthetic or paresthetic before are more nearly normal. After a few hours or days the symptoms and signs often reappear. For this reason it is necessary to keep the patient under observation and repeat the injections as often as necessary. Occasionally a single injection is sufficient to effect a cure.

3. During treatment the hand should be allowed to rest in a position of comfort, held in a sling to support the circulation as far as possible. It is best to avoid any form of passive manipulation or physiotherapy in the early stages.

4. Time is the great healer, and with the aid of novocain injections, gentle elastic traction, and carefully supervised return to active use, many of these patients are rehabilitated. Their mental attitude plays an important role and special care should be taken to get their complete cooperation, and to encourage them as to the eventual return to useful work. In very persistent cases, Leriche and others advocate injection of the cervical stellate sympathetic ganglion, or even its surgical removal. In their hands this is an effective, though radical, method of treatment if done early enough.

## CONCLUSION

Restoration of function and appearance of the burned hand demands a thorough knowledge of the anatomy and physiology of the part. The amount of tissue loss and tissue damage must be accurately gauged, and the repair must be planned accordingly. Skin grafts and skin flaps provide the material for reconstruction and the type to be employed must be judiciously selected. Proper means must be employed to obtain the utmost return of function. We still fall far short of our desired goal, and much progress by the surgeon remains to be made in reconstruction surgery of the burned hand.

## REFERENCES

1. Pierce, George Warren, and O'Connor, Gerald Brown: Pedicle Flap Patterns for Hand Reconstruction, Surg., Gynec. & Obst. 65: 523-527, 1937.
2. Miller and deTakats: Post-traumatic Dystrophy; Sudecks Atrophy, Surg., Gynec. & Obst. 75: 553-552, 1912.
3. Leriche: Surgery of Pain, Baltimore, 1939, Williams & Wilkins Company.

# PLASTIC REPAIR OF EXTENSOR HAND CONTRACTURES FOLLOWING HEALED DEEP SECOND DEGREE BURNS

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THE present conflict with its newer types of warfare equipment has given rise to many burns among the military personnel. Blasts from high explosives and the fires from burning oil have produced a type of injury that has not been observed to the same degree either in previous wars or in civilian practice. While any exposed surface is subject to injury, one of the more frequent sites is on the extensor aspects of the hands. So commonly are these seen, that they might well be looked upon as an occupational injury. When a bomb explodes, a "flash burn" is likely to occur to those working near by. The personnel within range will unconsciously place their hands in front of their faces and consequently the brunt of the flash burn takes place on the exposed extensor surfaces of the hands and fingers. Since the forearm is usually covered by a shirt or blouse, these areas are ordinarily spared. In naval warfare, an enemy plane not uncommonly crashes on the deck of a ship. When an explosion follows, flaming oil and gasoline are sprayed about in all directions. Those unfortunate enough to be working within range are often burned by the spraying flames. Again the dorsal surface of the hands and fingers is exposed to the flaming material dropping from above. As one would expect, the majority of these injuries are bilateral.

## SYMPTOMS

While burns arising from these sources may be classified into the first, second, and third degree types, the scope of this communication deals chiefly with those second degree in character. As a matter of interest, however, it is fortunate that the percentage of third degree burns is in the minority. Healed superficial second degree burns produce no problem worthy of mention here, but those of the intermediate group apparently have not been too well understood.

The deep second degree burn will naturally heal spontaneously because of regeneration from the remaining deeper elements of the skin and sebaceous glands. Unfortunately, however, a large amount of fibrosis develops in this newly formed covering and at times it is of sufficient degree to make difficult the distinction between it and those contractures arising from third degree burns that have been permitted to

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heal spontaneously by epithelization. The covering is rough, dry, and scaly and in many instances develops a keloidal type of hypertrophy. Complete flexion of the fingers is difficult or impossible because of the inelasticity of the covering. Forced attempts to produce flexion cause the skin to crack and break open over the metacarpophalangeal joints. The circulation is impaired so that in cold weather the damaged areas become cyanotic and tend to break down if not protected.

The symptoms pointed out are very apparent to all those who have dealt with injuries of this type. The situation is, of course, most pronounced in a kinetic structure such as the hand but might well be of little importance in a surface of lesser mechanical activity, as, for instance, the back or abdomen.

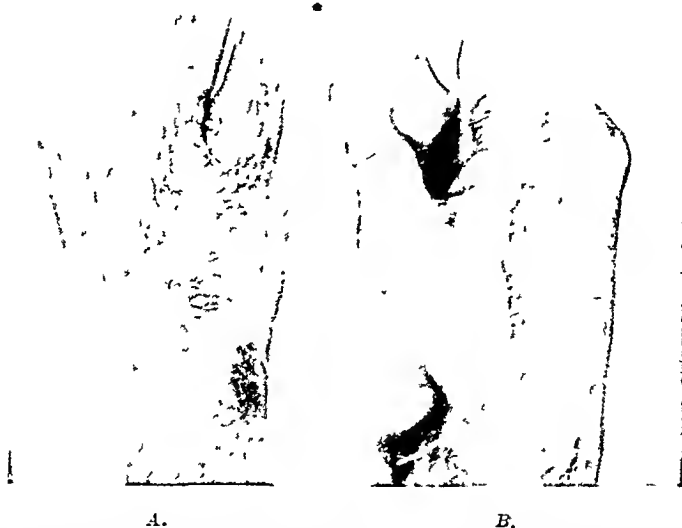


Fig 1—A, Healed deep second degree burns of right hand with marked limitation of flexion of fingers and wrist joint. B, After excision of dorsal contracture and replacement with thick split-thickness skin graft. Note flexion permitted by this near-normal elastic covering.

#### PATHOLOGY

A study of a typical microscopic section of this tissue shows the surface to be covered by keratinized stratified squamous epithelial cells whose rete pegs are flattened and in some areas absent. The connective tissue is poorly vascularized and is almost acellular. The subjacent tissue is dense and fibrous

#### TREATMENT

The correction of the contractures that follow deep second degree burns always has been handled from the more conservative point of



view which unfortunately has often fallen short of yielding the most desirable end result.

Physiotherapy in all forms has been utilized to treat injuries of this type. Occupational therapy, too, has been added. Irradiation in an attempt to soften and prevent fibrosis is likewise a favorite treatment. However, many of those with deep damage show very little response because of the unyielding fibrosis that extends throughout the healed epithelial covering. Consequently, the symptoms continue to persist until the fibrotic covering has been completely excised and replaced with another having normal elastic characteristics. In view of these findings it has been our experience that the conservative attitude in the management of this type of burn complication has given very unsatisfactory results.



B.

A.

Fig. 2.—A, Thick fibrotic dorsal covering on right hand. Left hand was in similar condition. B, Condition of both hands after excision of damaged extensor surfaces and replacement with thick split-thickness skin grafts.

Assuming the other viewpoint of what at first seemed more radical has in the final analysis compensated both the surgeon and patient with a far superior permanent covering. Being dissatisfied with the poorer end results, we have been following the policy of excising these fibrotic coverings as soon as it becomes apparent that further spontaneous improvement is hopeless. After excision, the cutaneous defect is covered immediately with a properly selected type of skin graft. The type chosen must furnish good elasticity in its substance and at the same time avoid utilizing complicated technical methods.

Our operations are done, preferably, under local anesthesia. This aids in hemostasis and, since the operation is not of brief duration, the additional burden of general anesthesia is avoided. Premedication consisting of nembutal,  $4\frac{1}{2}$  gr., two hours before surgery eliminates subjective apprehension. As a matter of fact, most patients sleep through most of the operation but can be aroused at any time to answer questions.



Fig. 3.—A, Result after replacement of extensor contractures with thick split-thickness skin grafts from chest. B, Note excellent elastic coverings provided by this relatively simple type of skin grafting procedure.

A blood pressure cuff placed around the upper arm and maintained at a pressure of 200 mm. of mercury gives, in conjunction with the local anesthesia, a very dry operative field. In the process of excising the scar, one must be careful not to injure any of the underlying dorsal veins or subcutaneous fat. At the completion of this step the blood pressure cuff is released and hemostasis perfected with ligatures and hot compresses to perfect the bed for the reception of a skin graft. More recently, we have found it expedient to coagulate all minor bleeding points with diathermy. This maneuver has not seemed to interfere with the "taking" of the graft and at the same time reduces materially the operative time.

Since the underlying tendons are in the most part covered with a good subcutaneous fat pad, any type of pedicle flap is unnecessary. Occasionally a small segment of tendon may be exposed in part, but this can be closed by suturing over it a small portion of the adjacent fat. The defect may be covered with either a free full-thickness or a thick split-thickness skin graft, cut in one massive piece. All of our cases have been closed by the latter method because of its relative simplicity. These grafts are cut in one large segment to approximately 85 to 90 per cent total skin thickness. This serves to give a strong flexible covering and at the same time leaves enough of the deeper elements of the skin so that the donor site heals spontaneously.

The grafts may be obtained either with the Padgett dermatome or the Blair-Brown suction box and razor technique, depending upon the skill of the individual operator. We have used the thigh, abdomen, and chest for donor sites with uniform success. It must be pointed out, however, that grafts from the chest and abdomen can be taken with greater accuracy when the Padgett dermatome is used.

After cutting, the graft is secured to the defect on the hand and fingers with nonabsorbable sutures. Slits are cut in the distal end of the graft to fit over the fingers. Pressure dressings are applied and the hand and arm immobilized on a padded straight board splint. For pressure we prefer ordinary flat sterile gauze dressings and abdominal pads, feeling that we obtain a more even and flat distribution of pressure than is secured with some of the other dressings in current use.

Barring complications, the dressing is not touched for seven to eight days, following which it is removed. At this time the sutures are removed and any excess graft trimmed off. The pressure dressings are reapplied for another week. Beginning two weeks after the operation, the coverings are removed for daily soakings and passive exercises in warm sterile water. At the end of three weeks, healing has usually progressed to the point where all pressure bandages can be removed permanently. More active physiotherapy and use are then started and at the same time the patient is encouraged to resume gradually all normal activities. An early return to limited duty is permitted providing trauma is avoided until good sensation has developed in the grafted skin. This latter factor will ordinarily take from six to twelve months but should not be of any handicap if simple precautions are observed.

#### CONCLUSIONS

1. Deep second degree burns of the dorsal aspects of the hands and fingers are quite frequent in modern warfare.

2. While burns of this type heal spontaneously, a thick fibrotic covering commonly develops thereafter, which does not respond well to conservative therapy.

3. Replacement of the damaged skin by a single massive thick split-thickness skin graft gives an excellent final result.

#### REFERENCES

1. Greeley, Paul W.: Factors Influencing the Choice of Skin Grafts, U. S. Nav. M. Bull. (In publication.)
2. Greeley, Paul W.: The Plastic Repair of Scar Contractures, SURGERY (In publication).
3. Meherin, J. Minton, and Greeley, Paul W.: Rehabilitation of the Burned Hand, S. Clin. North America, Dec., 1943.

## REHABILITATION FOLLOWING SEVERE BURNS

### EXPERIENCES WITH VICTIMS OF THE BOSTON NIGHT CLUB FIRE

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INTEREST in the management of severe burns has been greatly stimulated by World War II and the recent night club fire in Boston. In the early general care of the burned patient, the importance of adequate plasma, of oxygen, if there has been damage to the lungs, and of general supportive measures is generally agreed upon. In the later care, transfusions and diets with adequate vitamins, minerals, proteins, and calories are vitally important and also generally agreed upon. Concerning the local care of the severely burned, however, there is not the same unanimity of opinion. The purpose of this communication is to discuss the early and late local care on the basis of the experience with the victims of the Boston fire treated at the Massachusetts General Hospital.

Ten of the thirty-nine patients admitted on the night of the disaster remained in the hospital more than two weeks because they had third degree burns of sufficient extent to require further treatment. Two guiding principles were followed in the management of these cases: one, to preserve and protect the unburned tissues from additional damage, and the other, to close the open wounds as early as possible with skin grafts. In this small group of patients with deep burns it was possible to evaluate the unorthodox method chosen for treatment, since every effort was made to control the factors that are known to cause cell damage and that are known to delay the optimal time for grafting. Many surgeons have held the opinion which Graham has wisely stated, "In comparing the values of different . . . treatments of burns, it is, of course, essential to bear in mind that the only kind of case which offers a real test is the third degree burn. Almost any form of treatment, if it is not harmful" and, he might have added, if it is not complicated by serious infection, "will suffice for the first and second degree varieties. Too often this simple fact is overlooked."

Invasive infection is the most serious and the commonest cause of destruction of living epithelial cells in the deeper layers of the skin and tissue cells in the subcutaneous layers. The bacteria causing this infection are seldom present immediately after the burn occurs, because many of the surface organisms, as well as the skin, are destroyed by the heat. They reach the wound by injudicious exposure of the burned surfaces to unclean surroundings with unmasked observers. The rehabilitation of the severely burned must start at the time of the first inspection of the

wound by red. contamination to a minimum. Therefore, all persons caring for the victims of the disaster, doctors, nurses, orderlies, and medical students, were masked and wore clean gowns.

On admission the patient's clothing, which, in most cases, was soaked by water from the firemen's hoses, was removed and the patient placed on a sterile sheet. The burned surfaces were carefully wrapped in sterile towels until measures to correct shock and improve the general condition had been instituted. The victims were transferred to a special casualty ward—a regular ward from which all patients had been evacuated. This became an isolation ward (masks, clean gowns, and restricted admission), and here, while the necessary plasma was being given, the definitive treatment of the burned surfaces was carried out with as careful asepsis as possible. Subsequent dressings were done in an operating room established in this ward and, later, when the special ward was discontinued, in a regular operating room reserved for these patients exclusively.

Common surgical practice in the definitive treatment of the burned surfaces has dictated careful débridement. All destroyed epithelial tissue is removed, and all blebs ruptured and the walls trimmed away to allow the escape of coagulated and uncoagulated serum beneath. The surface is then cleansed either by irrigation with sterile saline solution or by scrubbing with soap and water. Finally, tannic acid (Davidson) or one of the dyes is sprayed on the surface. Recently, from the teachings of Brown and McDowell and Allen and Koch, a fine mesh ointment gauze with an occlusive dressing is applied. The procedure is usually done in an operating room with full personnel on hand to assist. It must, however, be postponed until the patient is completely recovered from shock, because general anesthesia may be necessary and because the débridement itself is accompanied by considerable loss of tissue fluid which may cause a secondary fall of blood pressure. The delay in completing the definitive treatment opens the way to surface contamination because of the inadequate protection afforded by the hastily applied sterile towel or sheet.

In the victims of the Boston night club fire treated at the Massachusetts General Hospital, accepted surgical practice was not followed. No cleansing or débridement of the burned skin was done. All blebs were left unruptured. The definitive occlusive dressing was applied directly to the undisturbed surface. The procedure was carried out in the special casualty ward without anesthesia. In fact, some of the patients were still in moderate shock at the time. All wounds, however, were adequately covered within two and one-half hours after the first victim arrived.

This unorthodox method of treatment was not chosen because of inadequate help or inadequate facilities. Actually the hospital was well prepared for just such disaster because of plans made during the previous

eleven months to care for casualties from possible enemy action. There were well-organized surgical teams within call, there were abundant sterile surgical supplies on hand, and there was an efficient blood bank with large quantities of available plasma. The choice of method of treatment was deliberate. It was the result of a series of studies by members of the staff on problems related to burns, particularly the control of infection by chemotherapy and the effect of various agents on epithelial regeneration.

No débridement of the burned surfaces was done because evidence accumulated indicated that an increase in contamination of the wound resulted. Only by vigorous scrubbing of the surface could this contamination be reduced. However, the trauma of such scrubbing necessarily causes damage to viable cells and reduces the effectiveness of the important factor of tissue resistance in preventing invasive infection. All blebs were intentionally left unruptured and no surface debris was disturbed. This plan was justified by the absence of growth in cultures of bleb fluid taken at intervals after the burn in these and other patients. Such results indicate that the intact outer wall of the bleb acts as adequate protection, preventing the penetration of pathogenic organisms from without. Even the epithelium lying on the surface after rupture of a bleb acts as a protecting membrane and was not removed. Each patient was given a prophylactic dose of 2 Gm. of sodium sulfadiazine intravenously about three hours after admission. Subsequently, sulfadiazine was given by mouth in dosages of 6 Gm. daily. No sulfonamides were used locally for two reasons: first, because of inability to control absorption accurately and, second, because evidence from clinical studies indicated that the sulfonamides are present in effective concentrations in the bleb fluid even if the initial dose is given as late as forty-eight hours after the burn. Sulfadiazine determinatives in these and other patients with early administration of the drug revealed practically identical concentrations in the blood and bleb fluid. On the sixth day in one patient, a level of 6.7 mg. per cent of sulfadiazine was found in the bleb fluid, with an associated level of 6.6 mg. per cent in the blood. After confirming the above observations, a case was selected for delayed administration of the drug. A single dose, 4 Gm., was given two days after the burn. Twelve hours later bleb fluid and blood samples were taken. A level of 3.0 mg. per cent of sulfadiazine was found in the bleb fluid, with a level of 6.0 mg. per cent in the blood.

The reliance on tissue resistance and internal chemotherapy to control invasive infection was justified by the finding of hemolytic streptococcus in only two cultures among all the surviving patients. Both of these were taken at the first change of dressing on the fifth or sixth day. Cultures from areas of second and third degree burns at this time showed coagulase positive staphylococcus and gram-negative saprophytes. Subsequent cultures from these areas showed an increasing number of

saprophytes and decreasing numbers of staphylococci, except in the areas of third degree burn in which the staphylococci flourished in the slough. Although surface infection was present in the slough, there was no evidence of invasive infection in the surrounding skin. Marginal areas of second degree burn were well healed by the time the slough began to separate, and there was no evidence that any areas of second degree burn were converted into areas of third degree because of infection.

The average time before complete separation of the slough was twenty-five days. This is a longer interval than one normally expects the process to take. The relative freedom of the wounds from invasive infection may be of significance, since little pus and no abscesses were found beneath the slough when it was finally removed. In one patient, extensor tendons of the index and middle fingers were found exposed over the metacarpophalangeal joints for a distance of from 3 to 4 cm. The surrounding granulating wound, from which coagulase positive *Staphylococcus aureus* and *Bacillus proteus* were cultured, involved most of the back of the hand and extended to the tip of the proximal phalanges. In spite of the presence of staphylococci in the wound, these tendons were salvaged by being covered with a direct abdominal flap on the twenty-eighth day after the burn. Such a procedure would be hazardous in a wound with active infection.

The application of injurious agents on the freshly burned surface is another common cause of death of cells undamaged by the heat. Experimental studies on the rate of epithelial regeneration have been recently carried out comparing various agents recommended in the treatment of burns. The donor site from which a dermatome graft had been cut was used for this study because an epithelial defect of uniform depth was produced and because the factor of infection in retarding healing was eliminated. Comparisons of the rate of epithelial regeneration were made in subdivisions of the same donor site. Boric acid ointment, 10 per cent, lightly impregnated in a single layer of fine mesh gauze and held in place with a firm dressing was used as control treatment. The rate of healing beneath this dressing was compared with that of tannic acid, the dyes, and several ointments recommended in the treatment of burns. Healing with the control boric acid ointment gauze and the other ointments took place in about ten or twelve days but was delayed beneath the escharotics, in one patient as long as sixty days.

Since the above evidence indicated that the tanning agents delay healing, none were used in these victims. In the definitive dressing, fine mesh gauze lightly impregnated with boric acid ointment similar to that used in control treatment in the experimental studies was applied. The ointment gauze was placed carefully and evenly on the burned surfaces and covered with gauze sponges. In order to secure a resilient occlusive dressing, mechanics waste and an encircling bandage were applied. In the extremities the occlusive nature of the dressing seemed

to reduce the amount of plasma that escaped into the tissue, but about the face there was a redistribution of the escaping fluid with edema descending down the unburned chest wall below the level of the dressing.

The second guiding principle in the management of these patients was the closure of the open wounds as early as possible with skin grafts. The temptation to wait until burn wounds heal spontaneously is great, but many are so large that healing will never occur. Also, the epithelium in spontaneous healing is of poor quality and is easily damaged by the slightest trauma. But successful early closure by skin grafting demands aggressive and painstaking attention to local dressings and general supportive measures.

The reasons for early grafting seem obvious. First, a large unhealed burn is a debilitating lesion. There is chronic sepsis in the wound with loss of protein and body fluids. Progressive anemia is usually present. The patients become more emaciated as they draw on their body reserves. Only with concentrated feeding by mouth and supplementary intravenous feedings and transfusions can they be carried through the preliminary stages before grafting is done. For these reasons, each of the victims, after recovering from the initial shock, was given a carefully planned high protein, high caloric, and high vitamin diet. This was supplemented by intravenous feedings of amino-acids and by transfusions if clinical and laboratory observations indicated the need. The most severely burned patient received a total of twenty-five transfusions and daily amino-acids intravenously for about two weeks before the first graft was done.

The development of contractures can be avoided only by early covering of the raw surfaces with skin grafts. The normal healing of an open wound involves two processes: reduction in the size of the defect by contraction of scar tissue and epithelialization of the raw surface from the margins. The larger the wound, the greater will be the contraction before healing takes place, but in some instances contraction continues and complete epithelialization never occurs. Among the victims the first graft was done on the twenty-third day after the disaster and the last at four months. Most of the operations were done during the sixth week. A minor contracture developed in the neck of the most severely burned patient. There were no others, but on the back of the hands of two patients thick keloid has developed which will require further corrective procedures.

Maintenance of the patient's morale is another reason for early grafting. No group of patients suffers more mental and physical torture than the severely burned. The pain of repeated dressings tests the courage of the most stoical and may necessitate anesthesia for dressings. Morale is hard to maintain unless great care and patience are used in changing dressings and unless promise of relief can be given by early covering of the painful surfaces with grafts. There is always a striking change



in attitude when the wounds are closed, and one of the most striking is the return of normal appetite, resulting in a prompt gain of weight.

The final reason for early grafting is economic. The hospital stay can be reduced by grafting the burned surfaces early. Otherwise, it may be prolonged many months or even years. The average hospital stay of the victims of the disaster was eleven weeks, the minimum was three and one-half weeks, and the maximum, twenty weeks. During this time, one or more skin grafting operations were done on nine of the ten severely burned patients. The tenth patient had a small area of deep burn on the back which rapidly healed from the margins without grafting.

In preparation of the raw surfaces for grafting, constant wet dressings were applied with moderate pressure. The progress in clinical improvement of the wounds was checked by repeated cultures. At each change of dressing the surfaces were carefully cleaned with soap and water and loose debris mechanically removed. It would have been better to alternate the wet dressings with ointment dressings, but the patients did not tolerate the change because of the discomfort of the drying in the latter type of dressing. The constant moisture seemed to delay the reduction of edema in the granulations and the development of a firm smooth surface free from organisms, such as *Bacillus pyocyaneus* and hemolytic streptococci, which are known to interfere with successful grafting. Sulfanilamide powder in controlled doses was dusted on the granulations preoperatively in several instances. The edema subsided, and the surface drainage decreased with the treatment more rapidly than with the wet dressings alone. In two patients there was loss of graft on the backs of the hand. One of these patients had a plasma protein level of 5.5 mg. per cent at the time of operation, and in the other beta hemolytic streptococci were found in the wound. There were no losses of graft following the local use of sulfanilamide.

The split thickness graft is the ideal graft for covering large and small surface defects from burns. Large sheets of skin are available, and the donor site is healed in about two weeks with little or no scarring. Several crops can be taken from the same area if the donor sites are limited. In these cases split thickness grafts were used to cover the raw surfaces with the single exception of the patient mentioned above who had extensor tendons exposed and in whom a direct abdominal flap was used. A flap applied to a granulating surface is indicated only to preserve or protect moving structures which might be destroyed or whose function might be impaired if not covered promptly with skin and subcutaneous tissue bearing its own blood supply. The use of pinch grafts in burn defects is not advisable for several reasons. The surface grafted has an ugly mottled appearance occasionally with keloid between the grafts, and the donor site is badly scarred. Exposed surfaces covered with these grafts do not withstand mild trauma. None were used in these patients.

The skin on the dorsum of one or both hands and arms was deeply burned in nine patients. These areas were the first grafted for reasons of comfort and early restoration of function. The relatively small areas of third degree burn on the faces were grafted as early as possible for cosmetic reasons. The back was burned deeply in six patients. Several of them also had burns of the hands and arms which were treated first. During the interval, the backs healed so rapidly that grafting was necessary in only one patient. Small areas of the scalp were allowed to heal spontaneously; larger areas were grafted. Exposed cartilage of the ear in one victim was saved by adequate soft tissue drainage. The legs of two patients were grafted.

Keloid has developed in the hands of the two patients mentioned above in whom there was loss of the graft. It has also developed in several small areas of the neck and chin as well as the larger areas of the back where spontaneous healing occurred. Elsewhere there has been satisfactory surfacing by successful skin grafting.

Function of the hands has returned slowly because of inability to splint the hand in the neutral position. Flexing the fingers put the open wounds on the dorsum under tension, and the patients could not tolerate the pain. There was also blanching of the tissue over the joints which increased the danger of further tissue necrosis and exposure of the extensor tendons and the joints. Therefore, the fingers were allowed to remain in extension and the wrist in a neutral or slightly dorsiflexed position until, at operation, they were put in a more nearly normal position. With complete healing, recovery of function has been hastened by supervised physiotherapy with the use of whirlpool baths and local massage. There is normal extensor function in the hand of the patient who had the direct abdominal flap over two exposed tendons.

#### COMMENT

The ultimate purpose of any method useful in the local treatment of burns is to protect from secondary damage all cells not destroyed by the heat. Therefore, the evaluation of the unorthodox method employed in this group of patients depends on determining whether the healing time was prolonged because the burns were neither débrided nor cleansed before the first dressings were applied.

The usual healing time of uninfected second degree burns is from two or three weeks, which was the same interval of healing in these patients. Examination of the wounds at the first and subsequent dressings revealed no destructive invasive infection. The destroyed epithelial debris was dry, and the contents of the intact blebs were sterile. The failure to débride the wounds initially did not delay the healing of the second degree burns in any measurable degree.

In the patients with both second and third degree burns, the surface remained free from active infection during the first two weeks. By the

end of two weeks, the areas of second degree burn were healed, while, in the immediately adjacent third degree areas, slough was separating. Staphylococci and the saprophytes flourished in the slough but did not invade the living tissues. Little exudate and no abscesses were found beneath the slough. The first graft was done on the twenty-third day. In one patient, exposed extensor tendons were found and salvaged by being covered with an abdominal flap on the twenty-eighth day. It is apparent from these observations that the wounds were free from invasive infection and that there was no measurable delay in carrying out the reparative procedures.

It seems reasonable to conclude from these observations, both on the second and third degree burns, that débridement and cleansing need not be part of the definitive treatment. Tissue resistance and general chemotherapy can be relied upon to prevent invasive infection. However, for success, an ointment gauze should be used to allow drainage into the overlying dressing. The surface must not be sealed by an impervious membrane or a harmful eschar. Precautions should be taken to reduce contamination by careless exposure of the wounds at the primary dressing and by two frequent subsequent changes.

The importance of the general nutritional state in the spontaneous healing of burned surfaces and the preparation of these surfaces for successful skin grafting cannot be overemphasized. Only by early skin grafting can large burned areas be covered and the development of contractures be avoided.

#### SUMMARY

The experiences with victims of the Boston night club fire treated at the Massachusetts General Hospital are described, and the evidence which led to the unorthodox method of treatment is presented. The dangers of invasive infection and harmful escharotics to cells surviving the heat are stressed. The value of reliance on tissue resistance, internal chemotherapy, and occlusive ointment gauze dressings in promoting early healing of second degree burns and in preparation for repair of third degree burns with skin grafts or flaps is emphasized.

#### REFERENCES

- Allen, H. S., and Koch, S. L.: Treatment of Patients With Severe Burns, Surg., Gynec. & Obst. 74: 914, 1942.  
Brown, J. B., and McDowell, F.: Skin Grafting of Burns, Philadelphia, 1943, J. B. Lippincott Co.  
Canuon, B., and Cope, O.: Rate of Epithelial Regeneration, Ann. Surg. 117: 85, 1943.  
Cannon, B.: Symposium on Cocoanut Grove Fire, Ann. Surg. 117: 903, 1943.  
Cope, O.: Symposium on Cocoanut Grove Fire, Ann. Surg. 117: 885, 1943.  
Davidson, E. C.: Tannic Acid in the Treatment of Burns, Surg., Gynec. & Obst. 41: 202, 1925.  
Graham, E. A.: The Year Book of General Surgery, Chicago, 1942, The Year Book Publishers, Inc., p. 185 (editor's note).  
Lyons, C.: Symposium on Cocoanut Grove Fire, Ann. Surg. 117: 894, 1943.

## FREE TRANSPLANTATION OF THE NIPPLES AND AREOLAE

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THE purpose of this article is to give additional proof that free transplantation of the nipples and areola can be successfully performed. The method offers a distinct advantage over the usual types of mammary plasties in that the reshaping of the breasts is completed before any attempt is made to select the new sites for the nipples.

Numerous operations have been devised for reducing the size and improving the shape of the hypertrophied and pendulous breast. Simple amputation of the breast with complete disregard of the nipple is recorded as having been done in the early part of the sixteenth century. Amputation is inexcusable for the benign hypertrophied and pendulous breast.

Lotseh<sup>6</sup> and Martinez and Noel<sup>7</sup> were of the first to employ skin plastic operations for improving the appearance of the simple ptosed breast. Their technique consisted of various incisions of the skin about the nipple permitting it to be shifted to a higher position on the breast.

For the overly large pendulous breast, Mornard,<sup>8</sup> Lexer-Krashe,<sup>5</sup> Hollander,<sup>3</sup> and Passot<sup>9</sup> advocated a resection of the excess breast tissue, and at the same time an improvement of the shape. Of these, Passot's technique probably offers the best results. An incision is made around the areola, and a circular buttonhole incision is made at the newly selected site for the nipple. The skin above the nipple is undermined sufficiently to allow shifting of the nipple, intact with the gland tissue, to its new location. The redundant portion of the breast tissue with the overlying skin is then excised, leaving an incision to be closed along the submammary fold.

Joseph,<sup>4</sup> in 1922, was one of the first to advocate the two-stage operation for excessively large and pendulous breasts, since this method lessened the danger of necrosis of the nipple and areola. This operation consisted of a transfixation of the nipple with the mammary gland tissue to its new location in the first stage, and removal of the redundant breast tissue at a second stage.

The following year Axhausen<sup>1</sup> introduced his method of undermining the skin overlying the entire breast, permitting a free upward shifting of the breast with the nipple. The excess breast tissue was then removed from the medial and lateral aspects.

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Biesenberger,<sup>2</sup> in 1927, advocated his method of reducing and reshaping the breast by means of an S-shaped incision in the lateral portion of the mammary gland. The remaining breast tissue, with the nipple intact, was then rotated on itself to form a more conical shape.

Thorek,<sup>10</sup> in 1921, reported: "It is possible to disconnect completely the nipples and areolae from the subjacent beds and transplant them to a new position in the remodeled breast."

For some time I had wanted to attempt the free grafting of the nipples and the areolae, but the opportunity did not present itself until one and one-half years ago, when a negro woman was referred to me for complete removal of her breasts. Because of their tremendous size and weight she was unable to do any work. In addition, they caused her considerable discomfort. The patient voluntarily stated that it was absolutely immaterial with her whether or not the nipples were saved. This appeared to be the ideal case for first trying a free transplantation of the nipples and areolae.

#### CASE REPORTS

CASE 1.—R. F., a Negro woman, aged 34 years, was admitted to the John Gaston Hospital on May 18, 1942. Her chief complaint was very large breasts and backache (Fig. 1 A). The patient first noticed breasts increasing in size three years before admission. After removal of the uterus, both tubes, and both ovaries in 1940, the size of the breasts increased much more rapidly. For one year before admission to the hospital the patient had been unable to work because of the extreme weight and size of the breasts. If the patient was required to stand for any length of time, she had considerable pain in the upper part of her back and shoulders, as well as in the upper part of the anterior chest. When breasts were not supported, there was an intense itching of the nipples and areolae, together with a dull aching pain in the whole lower portion of the breasts.

The patient had always been well until she developed a pelvic inflammatory disease in 1940, for which she had a supravaginal hysterectomy and a bilateral salpingo-oophorectomy. Findings at operation were uterine fibromyomas, bilateral salpingitis of the left hydrosalpinx, left ovarian cyst, and bilateral ovariau atrophy. She began menstruating at the age of 14. Menses were twenty-eight-day type, six days' duration, and regular until about six months before the pelvic operation. The patient had been married ten years and had one pregnancy which terminated in a miscarriage in 1934. Physical examination was essentially negative for the breasts which extended down to the upper margin of the pubic bone. When she was in a sitting position, the breasts rested on the thighs. The skin of the supramammary region was very tight due to the extreme weight of the breasts. The areola of each breast measured about  $3\frac{1}{2}$  inches in diameter. If the breasts were allowed to hang, the nipples and surrounding skin became noticeably cooler.

*Operative Procedure.*—With the patient in a sitting position the new sites for the nipples and areolae were selected and outlined with brilliant green. A circular area of the desired size was outlined about the nipples which were to be transplanted. After the usual skin preparation, 1 per cent novocain infiltration was used as an anesthetic. With a very sharp scalpel, a near full thickness skin dissection was made at the new site for the nipple. This dissection was done as in obtaining a near full thickness skin graft, removing all the glandular portion of the skin, and leaving

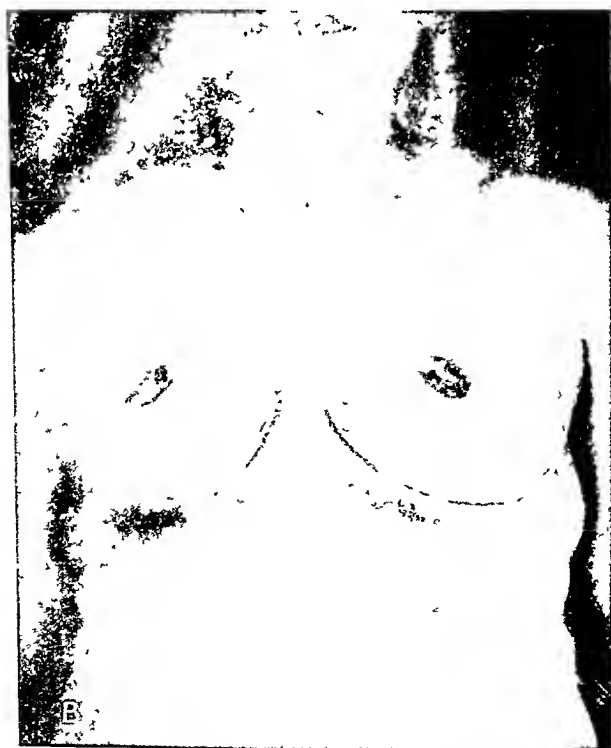


Fig. 1 (Case 1) —A Extremely large pendulous breasts in a Negro woman 34 years of age B One and one-half years after partial amputation, reshaping of the breasts, and free transplantation of the nipples and areolae.

only a very thin layer of the dermis at the base to expose the underlying subcutaneous and fatty tissue. The areola was then begun at the periphery, care being taken not to include any of the subcutaneous or fatty tissue. As the region of the dissection was gradually made deeper in order to obtain smooth muscle tissue (Fig. 2 A). This was done in order to insure a fraction of the smooth muscle. The nipples were then placed in place at their new locations. Four retention sutures were placed so that the graft would be evenly spread over the raw area (Fig. 2 B). A simple continuous suture of 4/0 Dekn. black silk was then placed around the periphery. The graft was sutured to the recipient raw area in a "quilting" manner, in order to insure immobilization and close contact. (Fig. 2 C). This procedure was repeated on the opposite breast, after which an elastic dressing was applied. The dressing was changed for the first time on the tenth postoperative day. There was a complete take of the grafted nipples and areolae.



A



B



C

Fig. 2.—A. Illustrating the dissection of the nipple and areola including a portion of the smooth muscle of the nipple. B. First step in the application of the nipple and areola graft to its new location. Four retention sutures are used to insure an even distribution of the graft. C. Technique used in suturing the graft to its new site. A simple continuous suture is placed around the periphery. The central portion is sutured to the recipient raw area in a "quilting" manner.

Two weeks later the patient was again taken to the operating room. She was given a general anesthetic, and by two semicircular incisions above and under the breasts along the submammary fold, the redundant portion of the breast was amputated. The remaining breast tissue was reshaped and held in place by several retention sutures of 00 elastic catgut. The skin margins were sutured together along the submammary fold. A pressure dressing was then applied over the breasts.

At the partial amputation and the reshaping of the breasts was undertaken, it was evident that the nipples had been grafted in too high a position on the breasts. This exemplified the disadvantage of transplanting the nipples before reshaping the breast.

The patient had an easy, uncomplicated postoperative recovery. Incisions healed by primary intention without drainage. About one month after operation keloid scars began to develop in the submammary incisions. Three x-ray treatments were given with successful results. About three weeks after the operation small brownish areas began to appear in the areolae as a result of a loss of some of the brownish pigment. Six months later all the normal pigment had reappeared. There was a definite erection of the nipples on manipulation, which could only result from the contraction of the smooth muscle grafted with the nipples. There was also return of normal tactile sensation of the nipples and areolae (Fig. 1 I).

retention sutures of 00 chrome catgut. The two raw surfaces of subcutaneous and fatty tissue underlying the skin margins were approximated with 00 plain catgut. Skin closure was made with interrupted No. 1 Deknatel and a continuous



Fig. 4 (Case 2) —A. Completed elastic immobilizing dressing. B. Dressing partly removed to illustrate the different layers applied in the following order, Xeraform gauze, dry gauze, rubber sponge, dry gauze and elastoplast.



suture of 3(0) Deknatel black silk. After the reshaping of the breasts was completed, and while the patient was still in a near-sitting position, the new sites for the nipples were selected and outlined corresponding in size to the nipple grafts. The circular areas of skin were dissected carefully, leaving only a thin basal layer of the dermis, and being very careful not to expose the subcutaneous and fatty tissue. After complete hemostasis was obtained, the nipple and areola grafts were sutured in their new location, as described in Case 1 (Fig. 2 B and C).

An elastic pressure bandage was applied in the following manner. Three layers of 3 per cent Xetaform gauze were placed immediately over the grafts and the incisions of the submammary folds. Dry gauze, 1 cm. in thickness, was next applied, then a rubber sponge of the same thickness. The central portion of the sponge which was to lie directly over the nipple was "saucerized" as a precaution against exerting too much pressure on the nipples. The rubber sponge was covered over with a thin layer of dry gauze. The dressing, at this point, was held in place with a few strips of plain adhesive. Both breasts were completely covered with a thin layer of dry gauze. Three-inch elastoplast was used to immobilize the breasts, and to help maintain their proper shape, obliterating any possible dead spaces, and to assure an even distribution of pressure throughout (Figs. 4 A and 4 B). The importance of the proper dressing cannot be too strongly emphasized, as the success of the operation depends largely upon its application.

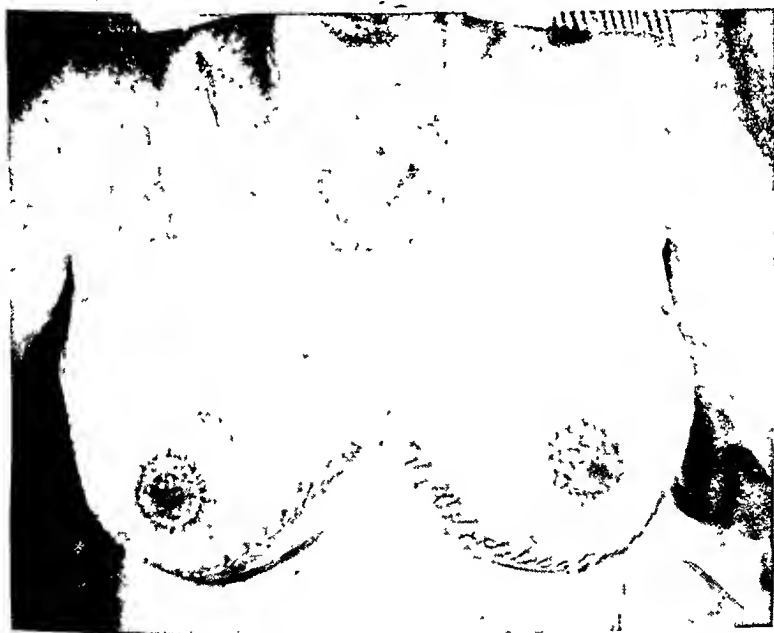


Fig. 5 (Case 2).—Appearance of the nipple and areola grafts at the first dressing, ten days postoperatively. There was a complete take of the grafts.

The dressing was inspected daily to be sure that proper pressure was maintained, and that there was no odor or drainage present. Practically the only pain of which the patient complained was a backache in the lumbar region. This pain disappeared immediately after she was allowed to sit up.

The first postoperative dressing was done on the tenth day. There was a complete take of the nipple and areola grafts (Fig. 5). All sutures were removed, and an elastic pressure bandage was reapplied (Fig. 4 A).

The patient left the hospital on the thirteenth post-operative day. A pressure bandage was worn for two weeks, after which sufficient pressure and immobilization were maintained by a well-fitted brassiere. She was last seen seven months following the operation. The breasts were well proportioned in size and shape and were smooth and firm throughout. There were no areas of tenderness or soreness. Three months after operation, the patient began to have a return of normal tactile sensation of the nipples and areolae. They were quite normal in appearance. The nipples were definitely elevated above the surrounding areola tissue. Following a slight massaging there was a definite erection of the nipples and a constriction of the areolae tissue immediately surrounding them (Figs. 3 B and 6). This should definitely prove that there is a return of function of the grafted portion of the smooth muscle of the nipple.



Fig. 6 (Case 2).—Close-up photograph, seven months postoperatively, of the grafted nipple and areola on the newly shaped breast, illustrating the normal appearance of the nipple and areola after free transplantation.

#### SUMMARY

Free transplantation of the nipples and areolae is recommended for the correction of the extremely large and pendulous breasts. The removal of the redundant mammary tissue, together with the complete reshaping of the breasts and the free grafting of the nipples and areolae, can be accomplished in one operation. After the proper form and shape of the breasts has been obtained the selection of the new sites for the nipples may be more accurately made. A small portion of the smooth muscle of the nipples should be included in the grafts so that the nipples

will be elevated above the areolae, giving them a normal appearance. It is thought that nipple and areola grafts should take with the same relative assurance as the usual free full thickness skin graft.

## REFERENCES

1. Axhausen: Med. Klin. 38: 1438.
2. Biesenberger: Zentralbl. f. Chir. 55: 2382, 1928.
3. Holländer: Deutsche med. Wchnschr. 50: 1400, 1924.
4. Joseph: Deutsche med. Wchnschr. 51: 1925.
5. Lexer-Krashe: München. med. Wchnschr. 51: 26, 1925.
6. Lotsch: Zentralbl. f. Chir. 50: 1241, 1923.
7. Martinez and Neel: Arch. franco-belges de chir. 31: 138, 1928.
8. Mernard: La Pratique Chirurgicale illustre Prolapsus mammaire, 1926.
9. Passot: La Chirurgie Esthetique Pure, Paris, 1931, Gaston Doin.
10. Thorek: Breast Reconstruction, Am. J. Surg. 43: 268, 1939; New York State J. Med. 116: 572, 1922.

# SIMPLIFIED METHOD OF ROTATING SKIN AND MUCOUS MEMBRANE FLAPS FOR COMPLETE RECONSTRUCTION OF THE LOWER LIP

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DEFECTS of the lower lip result from inflammatory or degenerative processes, as advanced carcinoma<sup>1, 2</sup> and extensive ulcerations (noma); or traumatism from burns<sup>3</sup> or other accidents.<sup>4, 5</sup> That reconstruction of these defects has been a surgical problem for many years is evidenced by the fact that according to Pierce and O'Connor,<sup>1</sup> over sixty-five methods and modifications of repairing complete or partial defects of the lower lip have been described in the literature. According to Martin,<sup>6</sup> von Bruns,<sup>7</sup> as early as 1859, had found thirty-two methods described by fifty-two authors. That there have been so many different methods for the correction of this defect is indicative of the inexpediency of any one method. This fact should decri, on the one hand, the advancement of a new technique which may be only as good as others previously advocated, and yet, on the other hand, should be a stimulant to the development of a technique which fulfills satisfactorily all surgical requirements.

Cheiloplasty for carcinoma of the lower lip, one of the oldest operations known, has been practiced since the days of Celsus (born about A.D. 25).<sup>8</sup> He is generally considered the originator of a method, the principle of which is still adhered to today—V-shaped incision and modifications including horizontal incisions from the angles of the mouth and along the lower edge of the mandible forming two lateral flaps of the cheek. According to Foman,<sup>9</sup> the Hindus utilized rotating flaps from the adjacent tissues to rebuild a defect of the lip; this later became known as the Indian method. Tagliacozzi is accredited with the first description of a technique using flaps from the arm (1597).<sup>9</sup> Chopart,<sup>10</sup> in 1785, reported the use of advancing flaps from the neck and chin for this purpose. Most of the operations advocated today are modifications of procedures, the basic principles of which were recognized in the early nineteenth century.

Bernard<sup>11</sup> and Burow and Saemann,<sup>12</sup> in 1853, devised an operation in which full-thickness triangles were removed from the upper lip and discarded. The lower lip was then built by loosening and pulling the sides of the cheeks to the midline over the mandible. This procedure was modified by Steward,<sup>13</sup> in 1910, and Martin,<sup>6</sup> in 1932.

In 1877, Estlander<sup>14</sup> proposed a procedure which is one of the recognized methods of lip reconstruction today. A V-shaped incision is made. A similar defect only one-half the size is outlined at the outer border of the corresponding upper lip and excised completely, excepting the tissue where the coronary artery of the lip is located. The upper triangle is then turned down into the lower lip and sutured. In 1936, Padgett<sup>15</sup> modified this operation by bringing the outer part of the lower lip to the center to form the middle portion of the lip. The outer part is repaired from the upper lip flap. There have been innumerable modifications of the Estlander operation.

An extensive lower lip defect is usually reconstructed by some form of pedicle transplant, sliding,<sup>16</sup> rotating,<sup>17</sup> or advancing.<sup>10</sup> These transplants may be rotated from the tissue above together with a portion of the upper lip, they may be rotated from tissues beneath and lateral to the chin upward to rest on a buttress of tissue, or they may be rotated from the tissue above and lateral to the upper lip with the pedicle attachment incorporating a portion of the upper lip. In most methods of rotation flaps the necessity of a lining for the pedicle is ignored and frequently the mucous membrane lining the lips is overlooked. It is not unusual for the surgeon attempting reconstruction to underestimate the amount of tissue necessary to obviate the possibility of subsequent tightness of the lips. Consequently, a foreshortened, noticeably tight lip, which permits drooling, invariably results.

Sliding flaps, commonly fashioned from the tissues of the cheek lateral to the defect, are usually outlined by parallel incisions from the defect backward to the region at the anterior border of the ramus of the mandible. These flaps are, of course, as wide as the defect of the lip. This method is objectionable because it produces a tight lip which often breaks down because of the great tension. It is not only cosmetically undesirable but also functionally unsatisfactory; it narrows the orifice of the mouth proportionately, and makes the insertion of artificial dentures, when necessary, impossible.

There are numerous varieties of advancement flaps.<sup>1, 6, 19, 19a</sup> These might appear to be ideal from a cursory glance of the diagrams illustrating their formation. However, only casual study of these illustrations is necessary to realize that in most instances pedicle flaps cannot be fashioned and made to heal to conformity. Here, again, the common criticism is the resultant foreshortened lip and the failure to include the mucous membrane lining. Not only are there associated residual lateral defects following reconstruction in this way, but good functional result of the new lip is doubtful.

Occasionally, reconstruction of massive defects of the lower lip by the use of tube pedicle transplants from distant regions has been advocated.<sup>18, 20, 21</sup> Because the lip consists of two layers of skin with no

has been raised and shifted forward into the defect and found to be adequate, it is wrapped in moist saline gauze. The same pattern used for outlining this skin and muscle flap is then carried inside the mouth where the upper and outer point is held fixed again, and in the same

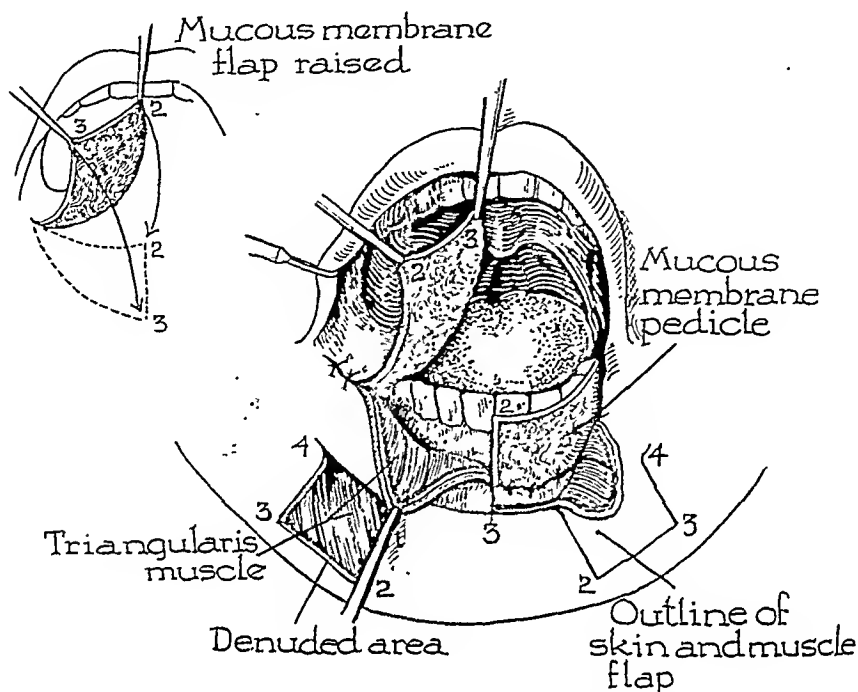


Fig. 4.—Drawing showing the advancement of the mucous membrane flap on the right cheek as it comes forward to join the skin and muscle flap. The mucous membrane flap on the left has already been advanced for the reception of the skin and muscle.

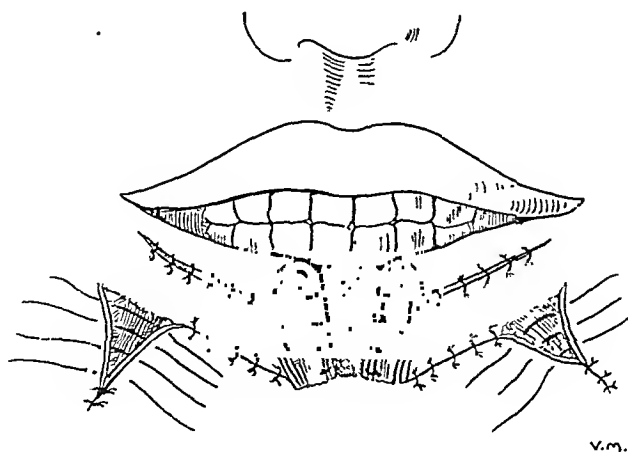


Fig. 5.—Drawing showing approximation of skin and muscle flap with the mucous membrane flap on either side. It also demonstrates the method of drawing the mucous membrane flap over the upper margin of the reconstructed lip where it forms the new vermillion border.

manner an area of mucous membrane identical in size and shape is raised and brought forward into the defect to form the lining of the lip (Fig. 3). The mucous membrane flap differs from the skin flap in only two essentials: it is not so thick and it is slightly wider. The purpose of this discrepancy in width is to enable the surgeon to bring the extra portion of mucous membrane over the upper border of the skin flap and

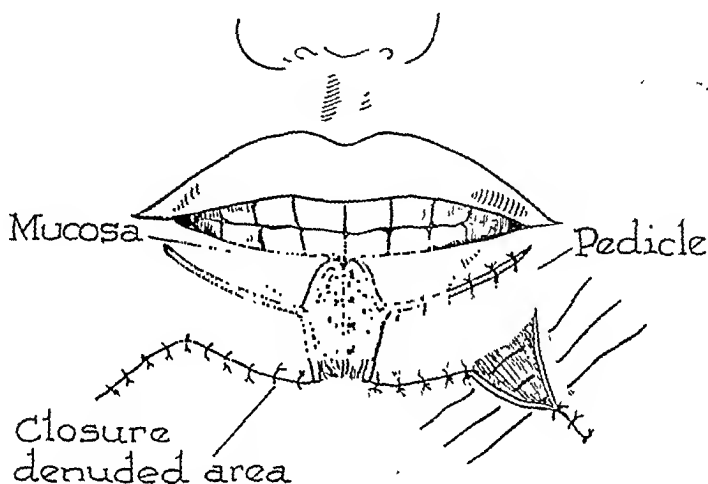


Fig. 6.—Drawing showing attachment of each composite flap with the other as they are joined in their final approximation to complete the newly formed lip.

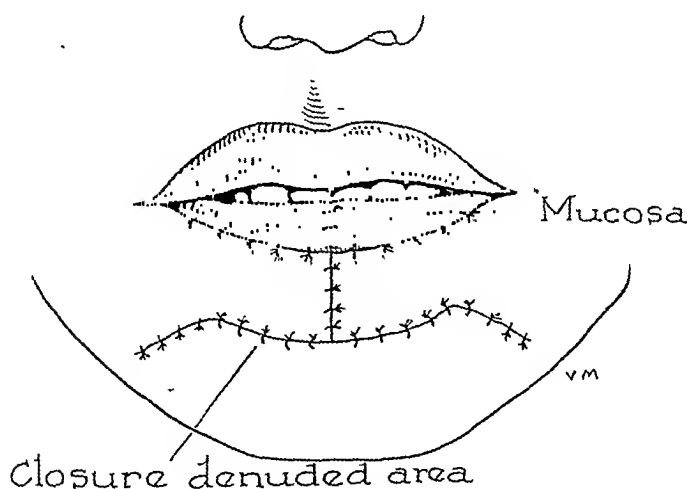
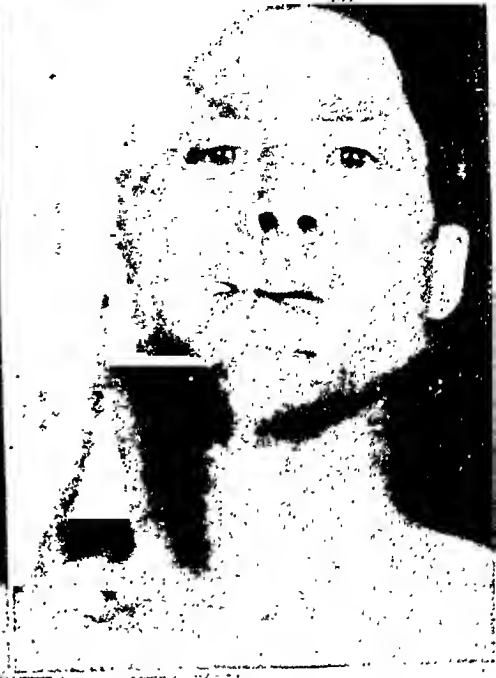


Fig. 7.—Drawing illustrating the completion of the reconstruction.

to suture it to the outer margin of the flap in such a way that it forms a covering for the upper border of the skin flap. This provides the vermillion border of the lip. Great care is taken to avoid injury to the Stensen duct. Following the dissection of the mucous membrane flap and its rotation into its anterior forward position, the defect is closed



*C.*

*D.*

Fig. 8.—*A*, Photograph showing extensive carcinoma around the right half of the lower lip. *B*, Photograph taken ten days after operation. Procedure designed to remove all carcinoma and to reconstruct completely the lower lip at the same time. *C*, Lateral view taken ten days following operation. *D*, Photograph taken approximately six weeks following operation. Although the details of the lip are obscured by the beard, one can see that the lip has undergone considerable relaxation and the tissues are softer and under less tension at this time.



by direct approximation (Fig. 4). If there is any apparent shortness in the length of the mucous membrane flap, it may be necessary to adjust the base of the pedicle. If the dissection has been carefully carried out and all measurements accurately followed, the mucous membrane flap will fall into apposition with the skin flap so that they adhere in a normal manner and the upper border of the skin flap will be adequately covered by the excess of mucosa (Fig. 5). This represents the reconstruction of one-half the lip defect. When necessary, for complete reconstruction of the lower lip, the identical procedure may be carried out on the opposite side.

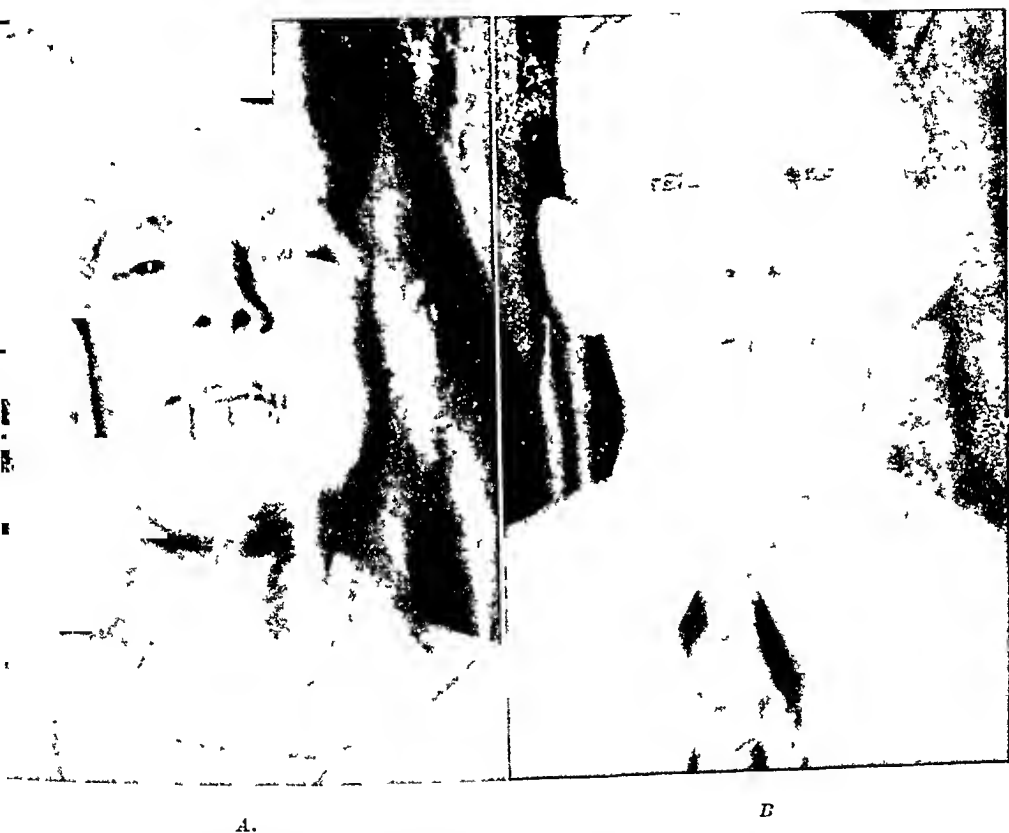


Fig. 9—A, Photograph showing defect resulting from removal of squamous carcinoma of the lower lip. B, Photograph taken approximately six weeks after complete reconstruction of the defect of the lower lip.

The defect inside the mouth, which should be sutured first, is closed with little or no difficulty by means of interrupted sutures of small black silk or 0000 silkworm gut. This line of closure continues along the entire inferior border of the newly formed mucous membrane flap (Fig. 4). The skin flap is then brought up into its position where it serves to reconstruct part of the defect of the lower lip, and the resulting defect lateral to the skin flap is closed by interrupted sutures of No. 1 black silk (Fig. 5). The flap usually will remain in place without tension.

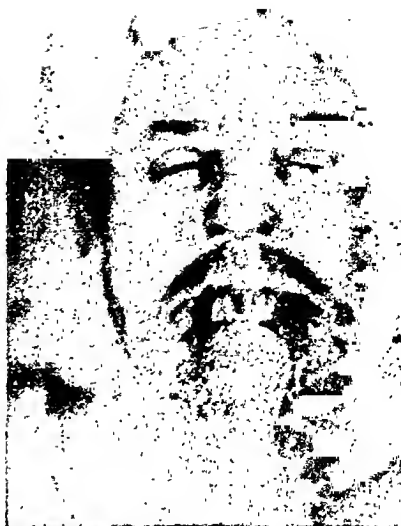


Fig. 10.

(For legends see opposite page.)

Fig. 11.

Approximation of the inferior margin of the skin flap with the margin of the defect is then carried out with interrupted sutures of 0000 silk-worm gut and an occasional suture of small black silk for tension. If this procedure is carried out accurately and meticulously there will be no tightness, shortness, or tension (Fig. 6). The excessive mucous membrane comes over the upper margin of the skin borders of the skin flap to form an entirely satisfactory vermilion border (Fig. 7). Two deep retention sutures of No. 50 white cotton are taken to hold the two skin flaps in close apposition in the midline. Other sutures of 0000 silk-worm gut are added as interrupted ones. Because of the danger of infection in this type of wound, a small rubber dam drain is inserted through a stab wound made in the skin below the reconstructed lip and carried up to the inferior margins of the new lip by blunt dissection with curved scissors. This is left in place for forty-eight hours. Because this type of wound is subject to excessive contamination and because of the possible development of Vincent's angina, except when contraindicated, a prophylactic dose of neoarsphenamine intravenously is routinely administered. An additional 5 per cent solution of neoarsphenamine in glycerin is applied three times daily along the suture line.

This procedure has been carried out on twelve patients. The cosmetic results have been uniformly good, the functional results gratifying in all twelve cases. It is significant that in all of these patients there has been a noticeable absence of tightness or shortness of the lips and in no instance has a patient complained of drooling.

## REFERENCES

1. Pierce, G. W., and O'Connor, G. B.: A New Method of Reconstruction of the Lip, *Arch. Surg.* 28: 317, 1934.
2. Daland, E. M.: Repair of Large Defects After Removal of Cancer of the Lips, *Surg., Gynec. & Obst.* 69: 347, 1939.
3. Roy, J. N.: Ectropion, pauphiere supérieure et lèvre inférieure à droite, consécutif à une brûlure; blépharo-labioplastie, *Rev. de chir. structur.* 8: 85, 1938.
4. Lombard, P.: Kheiloplasties, *Presse méd.* 47: 525, 1939.
5. Brohovic, H.: Kéiloplastie inférieure, *Rev. de chir. structur.* 210, 1937.
6. Martin, H. E.: Cheiloplasty for Advanced Carcinoma of the Lower Lip, *Surg., Gynec. & Obst.* 54: 914, 1932.
7. von Bruns, V.: *Handb. d. prakt. Chir.* Tuebingen, 1859, Laupp, pp. 694.
8. Foman, S.: *The Surgery of Injury and Plastic Repair*, Baltimore, 1939, Williams & Wilkins Company.
9. Tagliacozzi, G.: *De Curtorum Chirurgia par Institutionem Libri Duo* Venetius, 1597, G. Bindonus.
10. Chopart: Cited by Pierce and O'Connor.<sup>1</sup>
11. Bernard, C.: Cancer de la lèvre inférieure Opéré par un Procédé Nouveau, *Bull. Soc. de chir. de Par.* 3: 357, 1852-3.
12. Saemann, O.: *Die Transplantations Methode des Hrn. Prof. Dr. Burow*, Deutsche klin. 5: 221, 1853.

Fig. 10.—A, Defect of the lower lip resulting from extirpation of the carcinoma. B, Photograph taken approximately two months following reconstruction of defect of the lower lip. C, Lateral view of reconstructed lip taken approximately six weeks after time of reconstruction.

Fig. 11.—A, Defect of lower lip following extirpation of squamous cell carcinoma. B, Appearance of the lip approximately six months following reconstruction. C, View showing the ability of the patient to obtain good open bite following this reconstruction.

as a causative factor in the production of accidental deaths in this country, being surpassed only by automobile accidents and falls.

Children are constantly brought into hospitals for the treatment of burns which result from the upsetting of pots containing hot water, scalding foods, or drinks of various sorts. A child reflects a natural instinct when he grasps the handle of a pot to peer into its contents. Mothers are aware that their children are inquisitive, yet they seldom visualize the possibility of serious accidents which this quality can cause in their own kitchens. Full realization of this possibility should result in mothers' refusal to let children go into kitchens. Some mothers will contend that this is an impossible prohibition, stating that one cannot keep children out of kitchens, but I know from experience that it is possible to enforce such a household restriction. With a conscientious amount of instruction it is amazing to find children stopping short at the kitchen door and making no effort to go into forbidden territory. How much better to exercise a little effort toward a program of this sort than to experience the heartaches of watching a seriously burned child who may even lose his life as the result of a burn from hot fluid or food. Within the past three weeks, three such cases have been presented for treatment on one service in the city of New Orleans, indicating the relatively high incidence of burns from this cause.<sup>4</sup>

Every parent knows that a flimsy garment becomes a flaming torch when placed in contact with an open radiant heater and yet each year scores of helpless children (and adults) are presented for treatment with burns which resulted from this sort of thing. The obvious answer is thoughtlessness and lack of caution on the part of busy parents. A year-in and year-out program designed to remind parents of this hazard would do much to reduce the incidence of this class of burns. Another hazard equally as obvious is that of boiling water in open tubs. Every parent knows the danger of this and yet each year many children are brought to hospitals with severe burns resulting from contact with hot water in tubs. Many of these children plunge downward in attempting to investigate the contents of the tubs; others stumble and fall into the steaming water; others are placed in hot water by their own mothers, who assume that the water is of proper temperature. The danger of these hazards properly emphasized and constantly reiterated would do much in lessening burn mortality from these causes.

An educational program to reduce the incidence of burns should direct especial effort toward obtaining strict enforcement of laws prohibiting the sale of fireworks. The obvious need of this prohibition requires no discussion. The sale of this type of explosive to children is against any vestige of common sense and should be strictly forbidden at all times.

Numerous other instances of fire hazards, equally as obvious or insidious as the few common ones already listed, could be incorporated into a comprehensive educational campaign to eliminate some of the more

common causes of high mortality from burns. Such a survey, with adequate discussion of their relative importance in the production of such an alarming mortality rate, could not fail to effect a tremendous reduction. A perennial program which would continue to parade these facts before the general public until their hazard values were established would serve as a driving force in effecting still further reduction in the death rate from burns and in establishing a determination in the minds of countless parents and relatives to show a continued reduction in burn mortality.

The problem of reduction in the mortality rate by an educational program like that proposed is of definite concern to all plastic surgeons. All possible effort toward the development of such a campaign should be exerted by those concerned in advancing plastic surgery because the adequate care of burns embodies so many fundamentals of this specialty.

—*Neal Owens, M.D.*  
New Orleans, La.

## Book Reviews

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**Treatment of Burns.** By Henry N. Harkins, Henry Ford Hospital, Detroit, Ed. 1. Pp. 47, with 120 illustrations. Springfield, Ill., 1942. Charles C Thomas, Publisher. \$6.50.

This is a comprehensive monograph embracing the whole subject of burns. The physiologic aspects brought about by the extensive loss of the surface covering is well discussed. The many methods of local treatment of the burned area are discussed in detail. The tannic acid method, originated by the late Dr. Davidson of the Henry Ford Hospital, is given special prominence—perhaps more than current trends in burn treatment justify. The general management of burns with reference to the replacement of lost fluid and plasma is emphasized, and practical guides, for the determination of the amount of plasma to be administered, are outlined. The nutritional problem presented by patients surviving extensive burns warrants a broader discussion than that accorded this phase of the problem by the author. The plastic management of the late cases is well covered. Unusual complications attending burns, such as bleeding duodenal ulcer, are dealt with at length. This is a valuable treatise on the whole problem of burns and the monograph can be recommended enthusiastically as an important source book.

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**Plastic Surgery of the Breast and Abdomen Wall.** By Max Thorek. Pp. 446, with 458 illustrations. Springfield, Ill., 1942. Charles C Thomas, Publisher.

This book deals essentially with two conditions: (1) abnormal or pendulous breasts and means of surgical correction and, (2) lipectomy for the pendulous adipose abdominal wall. The author has approached the first subject from a very philosophic point of view. Racial and anthropological differences in breast conformation are discussed. The many operations which have been devised to correct breast deformities are reviewed in detail. The illustrations are particularly good. All surgeons interested in the plastic reconstruction of pendulous breasts will wish to acquaint themselves with this book.

The photographs before and after lipectomy exhibit in a striking manner what can be accomplished in appropriate instances by such an operative procedure. The possibility of fat embolism attending such procedure is deserving of mention.

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## Book Reviews

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**Treatment of Burns.** By Henry N. Harkins, Henry Ford Hospital, Detroit, Ed. 1. Pp. 47, with 120 illustrations. Springfield, Ill., 1942. Charles C Thomas, Publisher. \$6.50.

This is a comprehensive monograph embracing the whole subject of burns. The physiologic aspects brought about by the extensive loss of the surface covering is well discussed. The many methods of local treatment of the burned area are discussed in detail. The tannic acid method, originated by the late Dr. Davidson of the Henry Ford Hospital, is given special prominence—perhaps more than current trends in burn treatment justify. The general management of burns with reference to the replacement of lost fluid and plasma is emphasized, and practical guides, for the determination of the amount of plasma to be administered, are outlined. The nutritional problem presented by patients surviving extensive burns warrants a broader discussion than that accorded this phase of the problem by the author. The plastic management of the late cases is well covered. Unusual complications attending burns, such as bleeding duodenal ulcer, are dealt with at length. This is a valuable treatise on the whole problem of burns and the monograph can be recommended enthusiastically as an important source book.

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**Plastic Surgery of the Breast and Abdomen Wall.** By Max Thorek. Pp. 446, with 458 illustrations. Springfield, Ill., 1942. Charles C Thomas, Publisher.

This book deals essentially with two conditions: (1) abnormal or pendulous breasts and means of surgical correction and, (2) lipectomy for the pendulous adipose abdominal wall. The author has approached the first subject from a very philosophic point of view. Racial and anthropological differences in breast conformation are discussed. The many operations which have been devised to correct breast deformities are reviewed in detail. The illustrations are particularly good. All surgeons interested in the plastic reconstruction of pendulous breasts will wish to acquaint themselves with this book.

The photographs before and after lipectomy exhibit in a striking manner what can be accomplished in appropriate instances by such an operative procedure. The possibility of fat embolism attending such procedure is deserving of mention.



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The very great demand for the second edition sold it out so rapidly that the book has unfortunately been out of print for several months at a time when most needed. Despite war conditions and the emergencies of casualty surgery the author has managed to produce so thorough a revision that the new edition is unquestionably most comprehensive and well up-to-date with current war experience, as well as the treatment of civilian casualties.

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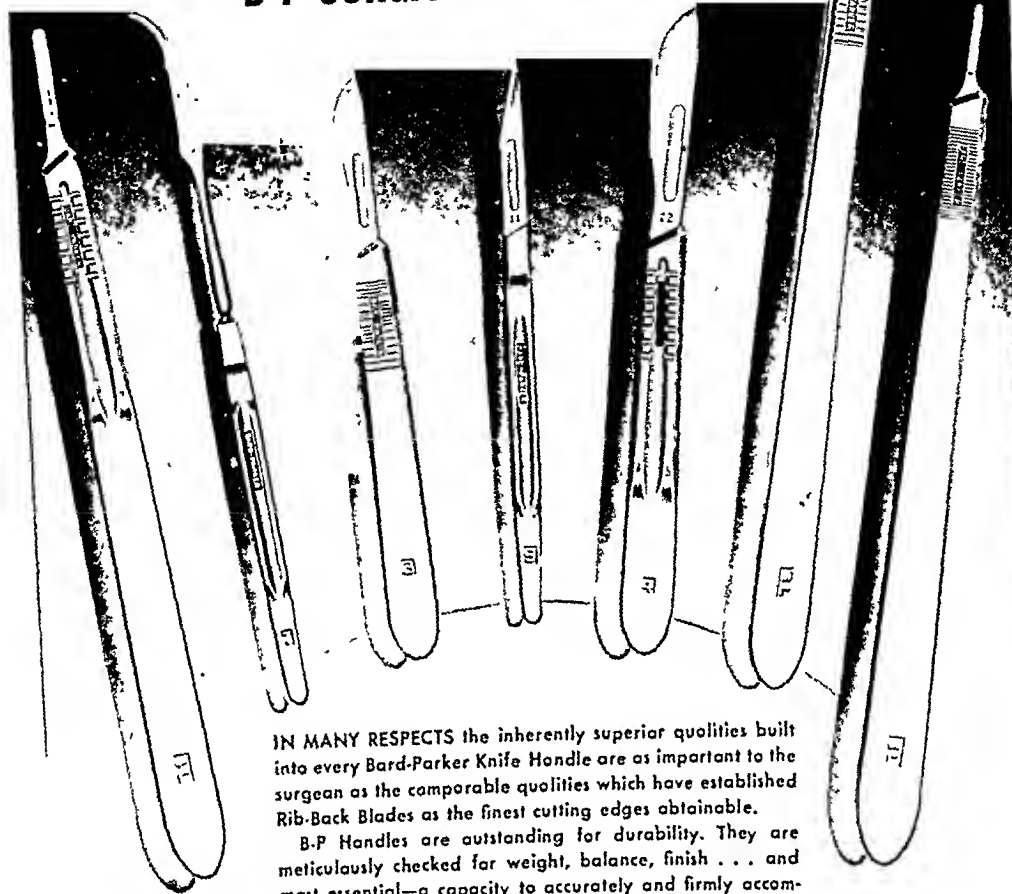
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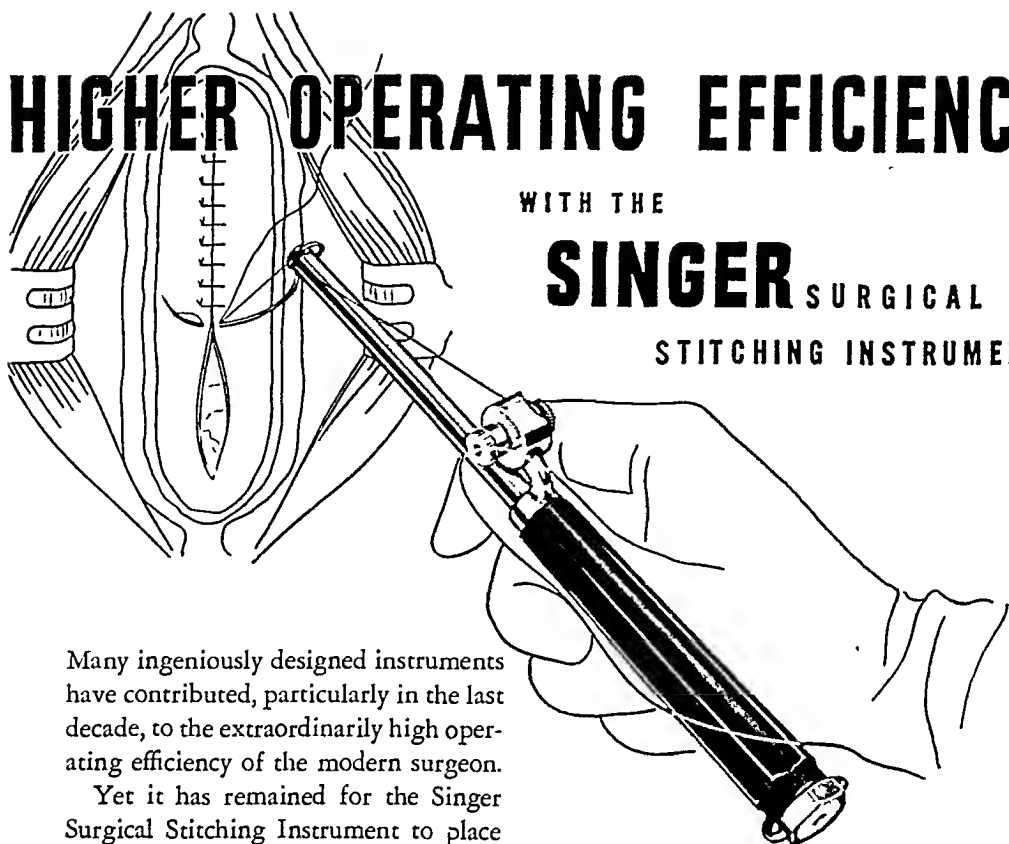
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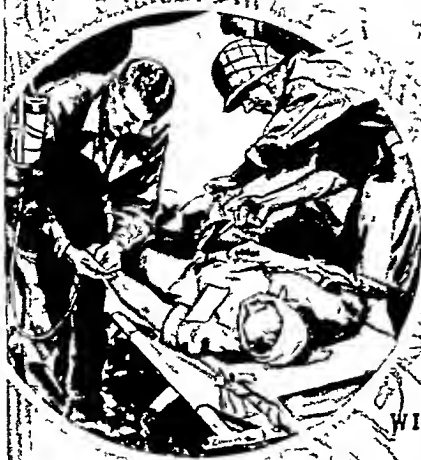
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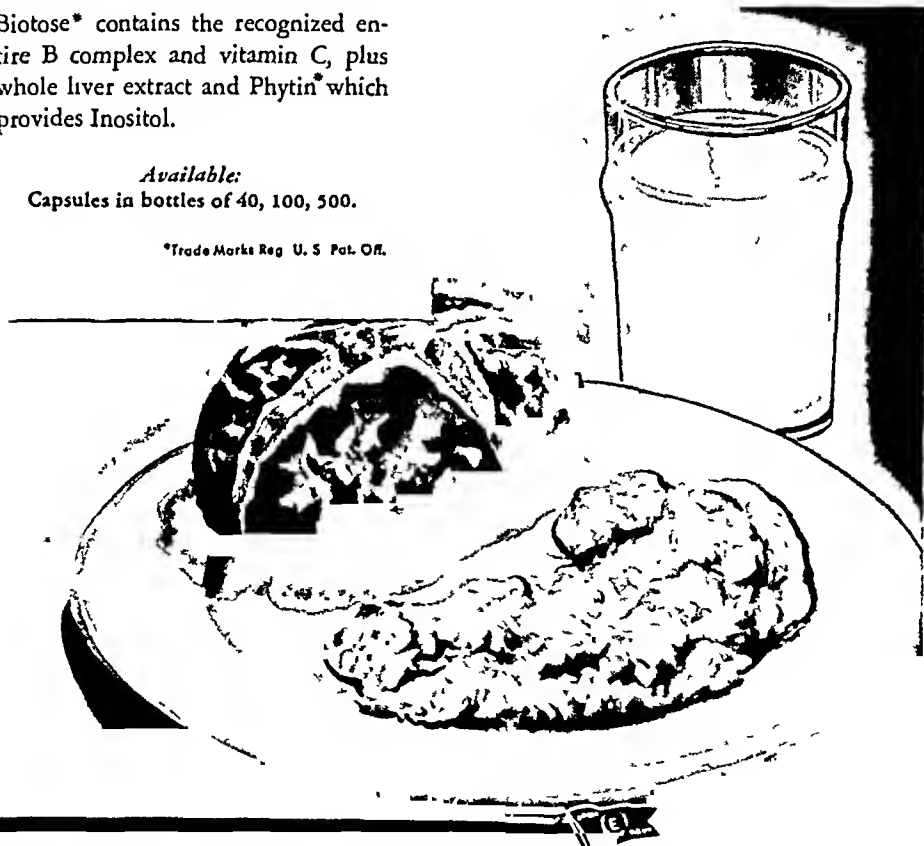
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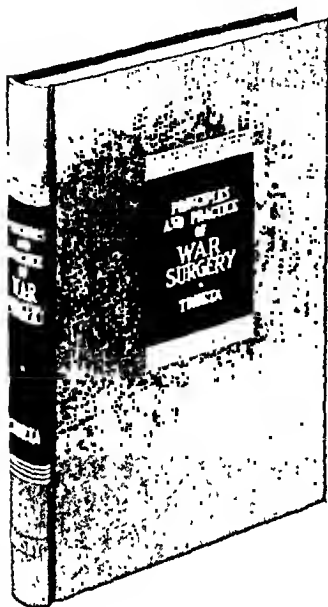
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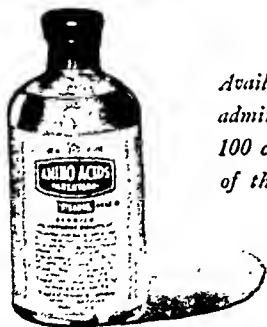
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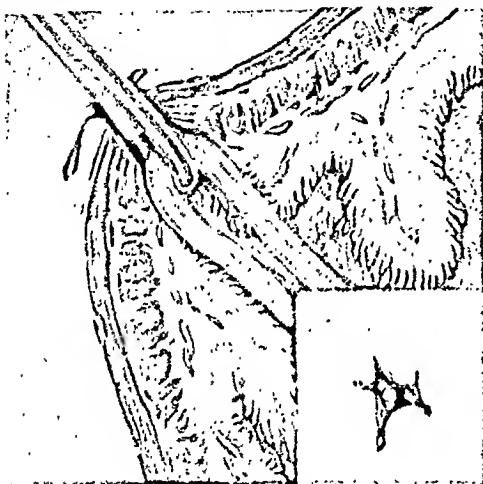
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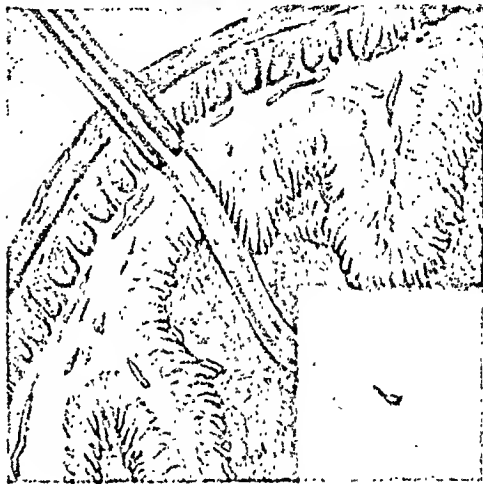
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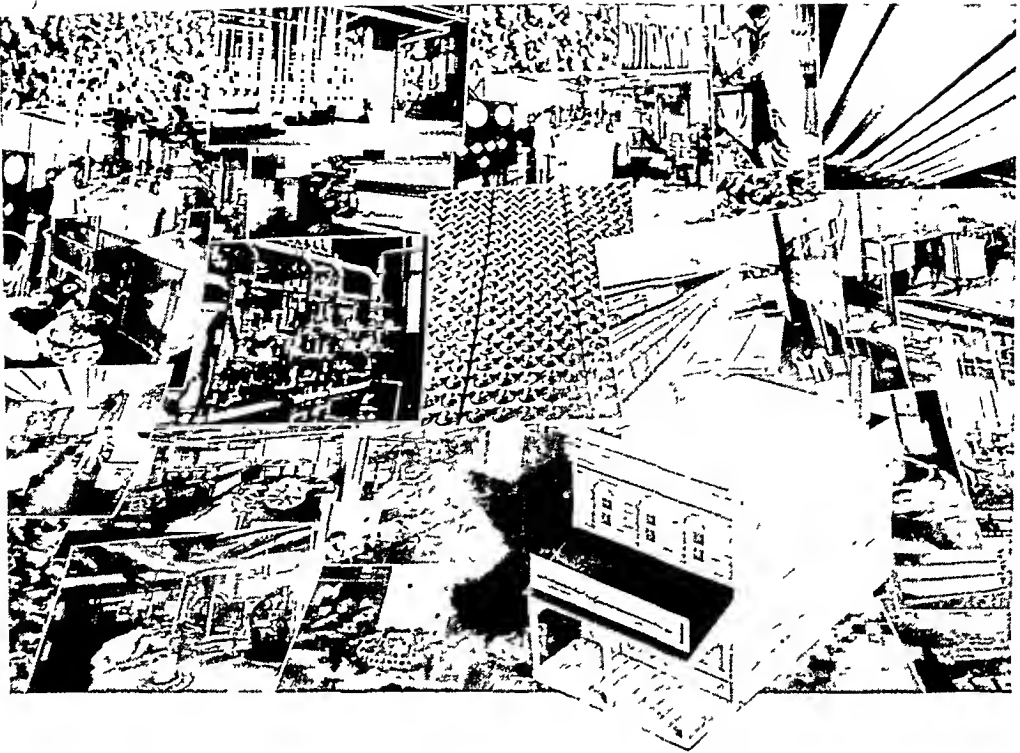


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## WILLIAM JONES, PH.G.

WHEN THE DOORS of the Jones Pharmacy opened for business many years ago, young Mr. Jones, then just out of pharmacy school, had some definite ideas about the manner in which a prescription department should be conducted. He knew all about fresh crude drugs, and he could triturate, macerate, and percolate with the best of them. He provided sparkling glassware, and his finished prescriptions were things of beauty. He operated very successfully and the doctors liked to have him do their compounding.

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**BUY WAR BONDS**

# SURGERY

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## Original Communications

### SURGICAL CARE OF THE WOUNDED IN THE UNITED STATES ARMY\*

MAJOR GENERAL NORMAN T. KIRK, SURGEON GENERAL  
UNITED STATES ARMY

ALTHOUGH in this war greater obstacles are encountered in providing adequate care of the wounded, the mortality and morbidity rates among our wounded are the lowest in the history of warfare. This gratifying achievement is the result of a carefully planned and intensively applied program of medical care which extends from the front line of battle to the general hospitals here at home. It is designed to save life by instituting treatment as soon after injury as possible and to restore maximum function by applying the most effective therapeutic measures known to medical science. That this program has been eminently successful is due to a number of factors, among the most important of which are intelligent mobilization, training and organization of personnel, advancing hospital facilities as close to the line of battle as possible in order to render prompt and specialized surgical care, increasing speed of evacuation of the wounded, and application and utilization to the fullest extent of the most modern developments in medical therapy. In addition to these factors, there is still another which has contributed as much or even more to the unqualified success of this program. This factor is concerned with the functional performance of our individual medical officers whose rapid metamorphosis from civilian to rigorous military life and ready adaptability toward their new responsibilities have been executed with remarkable efficiency. I would pause here to pay tribute to their inspiring devotion to duty, their physical and moral courage, their proficient skill, and the heartening enthusiasm, determination, and ingenuity which they have displayed in attacking their varied problems.

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\*The Eleventh H. Starr Judd Lecture in Surgery, University of Minnesota Medical School, Minneapolis, Minn., Dec. 6, 1943.

In order to permit a better understanding and appreciation of the problems encountered and the difficulties to be overcome in the adequate care of the wounded in this war and the plan upon which the modern scheme of medical care and evacuation has been based, it is deemed desirable to review briefly certain important considerations. It has been widely publicized that in contrast with previous wars this conflict is keynoted by a high degree of mechanization and mobility. This characterization demands thorough comprehension of the factors involved, in order to permit an adequate realization of the medico-military problems that are immediately posed in the adequate care of the wounded. Thus, during the active phase of engagements there may be a rapid progression of troops, leaving the wounded scattered over a large area, and even a constantly moving battalion-aid station will find it difficult to keep up with this advance. Many of these wounded must be sought on the battlefield where they lie after being hit and require litter transportation, the difficulties of which are further increased in regions of poor roadways and mountainous or jungled terrain. For similar reasons, their evacuation to the rear frequently requires fatiguing and time-consuming litter transportation. It becomes evident, therefore, that the first great obstacle in the administration of ideal treatment is the time elapsing between the occurrence of the injury and the institution of treatment. Another important factor in this connection is the greater power of ordnance which is being used in this war. As a result of these more powerful destructive agents, a higher incidence of severe injuries must be expected with consequent increased tissue damage and resultant shock. If these patients are to be saved they must be reached quickly, treated promptly, and handled gently. Even were their immediate removal from the battlefield to a hospital far to the rear possible, their condition of impending shock would make this highly undesirable. Still other problems which deserve consideration and which are unique in this war are those involved in the care of the wounded in amphibious operations. In these hazardous operations the difficulties of reaching and transporting the wounded and in providing adequate treatment are increased tremendously and the time factor is emphasized further. It has been a well-established principle that the sooner treatment of the wounded can be instituted the more successful are the results. This principle is emphasized in the plan of medical care in the forward area. The program is designed to overcome the difficulties enumerated previously which delay treatment, and to reduce the period between injury and institution of therapy to a minimum by shortening the distance between first-aid stations and units possessing the personnel and facilities for emergency surgical treatment and by constantly increasing the speed of evacuation. That these have been highly successful in overcoming the various obstacles described and in providing prompt surgical treatment is shown by the fact that the time elapsing between occurrence of in-

jury and first-aid care has averaged less than one hour, and between injury and emergency surgery at an evacuation hospital less than ten hours.

In order to permit a better concept of how this program of medical care and evacuation of the wounded in the combat zone functions, it is considered desirable to describe the component units of forward medical service and their mission. As previously stated, the program was planned with the view of utilizing every means possible to reduce to a minimum the time elapsing between the occurrence of the injury and the institution of therapy. Accordingly, treatment of the wounded in the combat zone is divided into two stages, i.e., the primary phase of treatment and the more definitive or emergency surgical treatment.

Each stage of treatment is provided by separate units with facilities designed for these respective purposes. The primary phase of treatment consists essentially of arrest of hemorrhage, administration of sulfonamides, application of occlusive dressings and splints, and the institution of resuscitative measures necessary to make the patient transportable. These are the urgent functions of the first and second surgical echelons which are comprised of battalion-aid stations and collecting and clearing stations. The lightly wounded, whose injury is such that treatment would permit immediate return to duty, are cared for in these stations. In addition, patients with injuries requiring immediate operation in order to save life can be treated in reinforced clearing stations. Provisions for emergency surgery of this nature may be made by attaching to certain clearing stations surgical teams properly staffed and equipped to perform these procedures. All other cases requiring emergency surgery are evacuated directly to evacuation hospitals in the third echelon. It should be emphasized that in this method of furnishing early surgical care of the wounded the plan of evacuation must not be regarded as an assembly line along which the patient receives part of his treatment at each station, but rather as a conveyance line along which the patient's condition is carefully checked and procedures to save life or to render him transportable applied. This may be better illustrated by describing the procedure that is followed from the time of injury until the wounded soldier is admitted to the hospital. All soldiers are carefully instructed in the principles of first aid which, depending upon the circumstances, they may apply upon themselves or upon their injured comrades. Company-aid men who are members of the medical department and specially trained in rendering first aid, proceed immediately behind combat troops and in certain operations actually go along with fighting troops. These company-aid men seek out the injured on the battlefield and apply first aid by administering morphine to relieve pain, by placing a dressing on the wound to prevent further contamination and to control hemorrhage. Litter bearers who are also near by and who follow the company-aid men, splint fractures, remove the casualty by litter, carry, and direct the walking wounded to the first-aid station which is as close to the

line of combat as is compatible with the performance of its mission. Depending upon the circumstances, this may be a few hundred to a few thousand yards behind the line of attack. A medical officer here carefully examines the wounded soldier, appraises his condition, and determines his priority in evacuation in accordance with the type and character of the wound. Plasma may be administered to combat shock, the control of hemorrhage is assured, wound dressings and splints are checked and, if necessary, secured and adjusted, and sulfonamides administered. As soon as feasible the patient is evacuated by litter to a collecting station which is located several hundred yards behind the battalion-aid station. At the collecting stations the wounded are again inspected, bandages and splints are adjusted, tourniquets are loosened, and dressings are changed if necessary. Additional plasma is administered in cases in which the threat of shock is present. As soon as it has been determined that the patient is transportable, he is evacuated to the clearing station which is usually a few miles farther to the rear. This is usually accomplished by ambulance, but may also be done by converted jeep or truck or by litter, under certain conditions of terrain. The clearing station is equipped to give more elaborate supportive therapy, but no actual surgery is performed here unless it is urgently indicated. The casualties are critically examined and classified in the receiving department or triage.

Many slightly wounded soldiers may be fit for duty after little or no further treatment. Patients in shock or impending shock are admitted to the shock section. Patients whose splints need adjustment or whose wounds require inspection or redressing are admitted to the surgical section. Certain types of wounds such as head wounds, sucking wounds of the chest, and abdominal wounds are given priority in evacuation to the hospital, but if the injury is such that further removal to the rear without surgery would be life-endangering, immediate operation may be done by the attached surgical team, if available. All other wounded are then evacuated to the nearest hospital staffed and equipped to perform adequate surgical treatment and possessing facilities for postoperative care, which in most instances is the field or evacuation hospital. Thus, it may be observed that the wounded soldier has been provided with the therapeutic measures necessary to save life and limb and to deliver him to the hospital in a condition permitting emergency surgical treatment.

At the evacuation hospital the first phase of definitive surgery begins. A careful assessment of the patient's general condition is made and necessary preoperative supportive measures applied. Roentgenographic or fluoroscopic examination is performed and the type and extent of surgery ascertained. The surgical management of the wound is then instituted. Whereas the fundamental principles involved in the treatment of wounds are similar no matter how incurred, in war wounds some operative measures are precluded and certain modifications are

neecessitated in accordance with military expediency. Thus, in civil life the wounded patient can be quickly brought to a fully equipped modern hospital and operated upon within a few hours. Under these ideal conditions where the patient can remain in the hospital until he has completely recovered and where he can be closely watched during this entire period by the same surgical team, the procedure of débridement and primary closure is admittedly the most desirable. In military practice these ideal conditions do not exist. Therapeutic procedures must frequently be done under adverse circumstances and expediency becomes an absolute necessity. Even were it possible to perform the débridement within a few hours after injury, it is rarely possible to keep the patient in the same hospital and under the constant watchfulness of the surgical team that does the operation until complete healing and recovery has occurred. The evacuation hospital has been so termed because it signifies its essential function. The patient must be evacuated to a general hospital as soon as his general condition permits transportation, otherwise the bed capacity of the evacuation hospital is soon reached and its function lost. The dangers of primary closure of the wound under these conditions are obvious and the soundness of the principle of leaving war wounds open after débridement becomes evident. Yet this principle in war surgery, which became well established in the last World War and reaffirmed in subsequent conflicts, is too often not observed by surgeons who have recently arrived in the combat zone, as well as at home. Disregard of this basic precept of war surgery almost invariably leads to disastrous consequences and is clearly illustrated by the following example: During the earlier part of a campaign in one of the overseas theaters, wounds were left open and practically no serious infections and only one case of gas bacillus infection were observed in the wounded évacués. Subsequently, the wounded from this area began to arrive with closed wounds and the incidence of gas bacillus infection rapidly rose to almost 2 per cent. Other mistakes which are commonly made by the uninitiated war surgeon are tight plugging of the wound by packs, failure to immobilize the site of injury, over-excision of the skin, failure to open deep spaces, lack of appreciation of the shattering power and extensive tissue destruction produced in war wounds, and failure to pad and to bivalve casts of the extremities.

It is, therefore, apparent that although the basic principles in the management of wounds are applicable, certain factors under war conditions deserve consideration. Every war wound must be regarded as potentially infected and its conversion into a clean wound is essential. In accomplishing this by performing débridement, emphasis is placed upon the following procedures: Because tissue damage is frequently more extensive than is apparent on the surface, adequate exposure to permit access to all parts of the wound is absolutely necessary. In doing this very little skin need be excised, but good exposure may require longitudinal incision of the skin and the fascial planes. Readily accessible

foreign bodies and especially pieces of clothing, particles of bone completely separated from the periosteum, and blood clots are removed. It is also important to excise all tissue that is soiled, devitalized, or has an impaired circulation. This is particularly true of muscle tissue. Hemostasis is effected and vaseline gauze dressings are laid loosely in the wound but not packed in. No sutures are to be used. These wounds must be left open. The part should then be immobilized by adequate splinting, even in the absence of fracture. A stimulating or "booster" dose of tetanus toxoid is routinely administered. In this connection it is noteworthy that no case of tetanus has occurred in American soldiers who have been properly immunized and have received these tetanus toxoid injections.

Although in general the surgical management of wounds of the soft parts in the evacuation hospital is essentially as described, there are certain distinctive procedures applicable to special types of regional wounds. Head wounds have comprised less than 10 per cent of all wounds. Because these patients do not withstand transportation well after operation, they are given priority (consideration) in evacuation to the hospital where adequate surgical treatment and postoperative care are feasible. Even a transport time of forty-eight or seventy-two hours does not contraindicate this policy since it has been demonstrated that operation can be delayed this long and more satisfactory results obtained in head wounds if this procedure is followed. At the hospital careful débridement of the scalp is done with every effort made to conserve as much skin as possible. In compound fractures, loose bone fragments and accessible foreign bodies are removed, and if necessary the bone defect may be enlarged, but extensive bone flaps are avoided. Evidence of an underlying clot demands opening the dura and evacuation of the clot. When the dura has been penetrated and damaged brain tissue is present, it may be removed by gentle irrigation and suction. These wounds must not be packed but should be closed around a small drain.

Maxillofacial wounds have been relatively few and have not constituted a serious problem. The important consideration in the emergency surgical treatment of these wounds is conservation of tissue in order to facilitate subsequent reconstructive procedures. Moreover, in contradistinction to the general rule of leaving war wounds open, these wounds should be closed if this can be accomplished without producing undue tension. It has been found preferable in cases with wounds opening into the buccal or nasopharyngeal cavities complicated by a compound fracture, to approximate the lacerated soft parts by bandage and adhesive strips rather than suture.

Certain types of chest wounds demand special attention. Sucking wounds of the chest require immediate closure and earlier in the war this was being done by emergency suture without adequate débridement. This frequently resulted in tension pneumothorax with consequent death



on the way or shortly after reaching the hospital. In others the wound soon became infected and broke open, thereby greatly increasing the difficulties of management. For these reasons it has been found more desirable to effect emergency closure by the application of a pad of gauze heavily coated with vaseline and folded to fit the wound. This may be held in position in large wounds by attaching it to the skin edges with a few sutures, over which a supportive gauze dressing is securely strapped. These patients are given priority in evacuation to the hospital where wound débridement and surgical closure can be properly done. Tension pneumothorax requires immediate relief by aspiration or release of air through a needle inserted into the chest. During evacuation the recurrence of tension pneumothorax must be considered and in order to obviate this it has been found best to arrange a flutter valve which can be fitted to the needle or small catheter which has been inserted into the pleural cavity. This can be made from thin rubber tissue such as that from an old rubber glove, a Penrose drain, or other items made of similar material. Novocain block of the intercostal nerves supplying the injured area has been found especially useful in controlling pain in cases of rib fractures and other chest wall injuries. Conservatism has been the keynote in the management of simple hemothorax. Simple aspiration to relieve respiratory embarrassment without air replacement has given the best results. Progressive internal bleeding is usually from the chest wall or from a large visceral or mediastinal vessel. This demands either revision of the wounds of entrance and exit or thoracotomy.

Whereas abdominal wounds comprise a relatively small number of all war wounds, they are particularly important because they contribute most to the case fatality rate. This is accounted for by the frequency and gravity of such complications as shock, hemorrhage, and peritonitis. The seriousness and early development of these complications demand emergency surgical treatment as soon after injury as possible. Moreover, these patients cannot tolerate early transportation after operation. For these reasons these patients are given priority in direct evacuation to hospitals where facilities exist for emergency surgical treatment and adequate postoperative care. Accordingly, depending upon the circumstances, they are treated by the surgical teams attached to a clearing station or at an evacuation hospital. In addition to the well-established principles that are followed in the surgical management of these cases, the procedure of exteriorization in large bowel injuries has been found particularly valuable. Indeed it may be considered as one of the important advances in military surgery in this war. The damaged segment of bowel is simply and expeditiously exteriorized by drawing it out through a separate incision, preferably in the flank. The formation of a spur greatly facilitates subsequent closure. The Levine tube and Wangenstein suction, along with sulfanilamide, have saved many lives in prevention and treatment of peritonitis.

Wounds of the extremities have always comprised the largest number of war injuries and in this war have accounted for about 65 to 70 per cent of all wounds. Obviously, from a medico-military point of view, they are the most significant type of war wounds. The preliminary surgical treatment of most of these cases is done at the evacuation hospitals and for wounds of the soft parts is essentially as described. However, nerve and blood vessel injuries and compound fractures, which are the most important complications of these wounds, deserve further consideration. The significance of nerve involvement is shown by the fact that from 12 to 15 per cent of all extremity wounds are complicated by injury to major nerve trunks. Accordingly, the possibility of this complication has been emphasized and efforts made to direct attention toward its early recognition. Primary anastomosis of severed peripheral nerves is not generally feasible but should be attempted if the nerve ends are readily accessible and can be approximated without tension. If this cannot be done, the injured nerve ends should be identified and a sling suture of fine stainless steel wire placed between them or they should be anchored with similar suture material to the surrounding tissue, in order to prevent retraction. Metal suture material is advocated here because it facilitates roentgenographic identification preceding subsequent repair. In order to minimize the irreparable degenerative changes that occur in the end plates of severed nerves, these patients are evacuated to neurosurgical centers in this country as soon as possible for operative repair and the necessarily prolonged postoperative care.

Peripheral vascular injuries, especially those involving major vessels, are also significant complications since they may lead not only to loss of limb but also to the loss of life. The vessel may be lacerated, partially or completely severed, thrombosed, or in acute spasm. In cases requiring ligation and in order to eliminate the dangers of secondary hemorrhage, thrombosis, and vasoconstrictor influences, the vessel should not be ligated in continuity but should be ligated well above and below the point of injury with excision of the damaged segment between these ligatures. A thrombosed segment should similarly be excised. Reflex vasospasm which not uncommonly accompanies these injuries should be considered. Concussion or localized segmental spasm of the artery may occur in cases in which the injury has involved tissues remote from the vessel, as well as in those in which the traumatizing agent passes near a vessel. In cases manifesting this phenomenon the limb appears cold, pale, and pulseless, although evidence of hematoma or laceration of the vessel may be lacking. Such cases respond well to débridement of the surrounding traumatized tissue, or to novocain block of the regional sympathetics. Vasodilation should be induced in all peripheral vascular injuries by sympathetic block, which may be repeated daily for several days if necessary. Extending the period of viability of ischemic tissues by refrigeration and consequent reduction of local metabolism is a re-

cent advance which, although deserving consideration, has not been developed to the point where it is practicable for forward echelons.

Bone and joint involvement in wounds of the extremities may be considered the most important of all these complications because of the protracted hospitalization and disabilities which they produce, especially if early treatment has been inadequate. The difficulties in the ideal management of these cases are greatly increased under war conditions. Moreover, the highly destructive shattering fractures, with great loss of bone substances that are commonly observed in such cases, emphasize further the problems encountered in their treatment. For these reasons efforts have been directed toward prompt and proper management along principles which under war conditions have been found to give the most satisfactory end results. The essential problem in the management of wounds of the extremities in the forward echelons is concerned principally with the most expedient and comfortable method of immobilization during evacuation. It must provide adequate fixation for ambulance or jeep transport over rough roads and at the same time assurance that the circulation of the extremity will not be jeopardized or that additional injury of the soft part will not be incurred. These desiderata are best met for fractures of the femur about the knee and both bones of the leg above the ankle by use of the Army half-ring splints with the litter bar, ankle strap, and five triangular bandages. Traction is effected by the ankle strap or hitch about the ankle with the shoe on and by skin traction with the shoe off. This method has been found the most satisfactory for evacuating patients with these fractures from the first and second echelons to the evacuation hospital or even to the general hospital. Skeletal fixation and skeletal traction in patients who are to be transported have resulted in much discomfort and in bone infection in the pin wounds. These procedures have no place in the management of these cases in the forward echelons. Following adequate débridement in the evacuation hospital, fractures of the shaft of the femur or tibia and fractures involving the hip or knee joints are evacuated to the general hospitals in the Army half-ring splint with skin or skeletal traction or in a padded plaster spica. In this connection the so-called Tobruk splint has received favorable comment and is applied as follows: by means of traction, preferably skin traction, the extremity is pulled down, a plaster splint is molded to the posterior aspect of the thigh and leg, a half-ring splint is applied, to which the traction is made fast, and the extremity and splint are wrapped by several turns of plaster. Padded posterior and lateral wire ladder splints are considered best for evacuating fractures of the ankle and foot. In transporting patients with fractures of the humerus from the more forward echelons to the evacuation hospital, the Thomas arm hinged splint with skin traction or the immobilization of the arm to the side of the chest with a sling or Velpeau bandage incorporating a padded external splint has been found satisfactory. For evacuation to a general hospital the best method consists

of use of a U-shaped molded plaster splint extending from the axilla around the elbow and up the outer surface of the arm and shoulder to the neck, supported by bandages and a sling. For fractures of the elbow and upper one-third of the forearm, immobilization is best effected by the use of a posterior wire ladder or molded plaster splint extending beyond the wrist and supported by a sling. Coaptation splints for forearm and hand should be used.

In the management of compound fractures in these forward echelons, adequate débridement is imperative and the principles described previously are followed. Whereas internal metallic fixation is at times a valuable procedure in the definitive treatment of simple fractures, its application in the emergency surgical treatment in these echelons is followed by frequent complications and failures. For these reasons the more conservative principles of careful débridement, leaving the wound open, covered with loosely placed fine mesh vaseline gauze, and followed by cast or splinting with skin traction are advocated. The importance of properly padding and completely bivalving all casts of the extremities prior to evacuation is emphasized.

Penetrating wounds of the joints are also treated by adequate débridement, removal of all loose bone fragments, irrigation of the joint cavity, and closure of the synovial membrane. The soft tissue wound down to the sutured synovial membrane is left open and covered with loosely placed gauze. Immobilization is obtained as previously described.

Because of the highly destructive and shattering injuries, particularly from land mines, that are incurred in this war, cases requiring amputation have been relatively frequent. In the performance of this procedure under war conditions there has been an unfortunate lack of familiarity with the principles involved. The most common errors of judgment have been concerned with unnecessary sacrifice of tissue and with closure of the stump resulting in osteomyelitis, gas gangrene, or other serious infections, or a stump that is too short. All emergency amputations in these echelons should be performed at the lowest level possible which permits removal of all devitalized and contaminated tissue regardless of stump length. Revision of the stump in accordance with prosthetic considerations may be subsequently performed. The open (guillotine) circular method, with severance of successive layers at the level of retraction of the preceding layers, resulting in an inverted cone rather than a square end stump, is the procedure of choice. The wound must be left open, using a vaseline dressing. Skin traction to the stump is always immediately applied following the amputation and continued until healing occurs. The flap-type open amputation may be done only in cases in which early evacuation is not contemplated and subsequent closure at the same installation is deemed possible, such as in a general hospital.

Although burns have comprised less than 2 per cent of the war wounds, because of the grave consequences they must be regarded as

constituting a serious form of injury. Recognizing the significance of burns and the controversial forms of treatment, the Army has concentrated its efforts on the prevention and treatment of this type of injury and has developed a therapeutic program which is giving increasingly better results. The principles upon which this treatment is based consist essentially of prevention and control of shock by the adequate use of plasma, relief of pain with morphine, prevention and control of infection by aseptic precautions and administration of sulfadiazine, and prevention of contractures and excessive scarring by proper splinting and early skin grafting. In the local treatment of the burned area, tannic acid and other escharotics are no longer used. Burns are now treated locally by the application of sterile petrolatum gauze and a firm pressure dressing. This method of therapy is designed to provide the greatest amount of comfort to the patient, to exclude infection in the local area, to protect the injured skin and allow as rapid recovery as possible, and to prevent swelling and loss of fluids locally. Increasing experience with this method of treatment shows that more lives are being saved and better results are being obtained than by any other method previously used.

In this description of the program of medical care and evacuation of the wounded in the forward echelons, the patient has been brought from the very front line of battle where he received the primary phase of treatment to a hospital a few miles to the rear where he received the more definitive or emergency surgical treatment. From the time of injury until his admission to the evacuation hospital, which is staffed and equipped to perform the respective forms of emergency surgical procedures that have been briefly presented, less than ten hours have elapsed. Thus, it becomes apparent that this plan for the care of the injured in the combat zone, which couples speed of evacuation with advancement of hospital facilities, permits not only application of lifesaving surgical measures, but also reduction of the serious complications and morbid consequences that would otherwise occur. It should be realized, however, that this general plan of forward medical service is not fixed but possesses sufficient flexibility to meet the demands of military strategy and varied problems of changing terrain. Under certain conditions clearing stations may be required to function as evacuation hospitals and collecting stations as clearing stations. These adaptations can be readily made by the use of mobile surgical units and the highly trained auxiliary surgical groups which are composed of specialized surgical teams including neurosurgery, maxillofacial and plastic surgery, orthopedic surgery, chest surgery, and general surgery. In jungle warfare in which transportation facilities are limited to human carriers, this purpose has been met by the use of portable surgical hospitals. In amphibious operations, hospital ships whose primary function is transportation of the wounded may be converted to perform this function. Thus, by these variable adaptations it has been possible to advance hospital facilities and to pro-

vide the prompt and highly trained surgical care of the wounded in the forward echelons under varied combat operations and adverse geographic conditions.

After the wounded have received the appropriate emergency surgical treatment indicated here, in the evacuation hospital, which is the last echelon in the combat zone, they are evacuated to the general hospitals. This is done as soon as the patient's condition makes him transportable and usually within a week after admission and treatment. Transportation is accomplished by the most readily available means. In some instances it is done by ambulance, converted jeeps or trucks, or by hospital trains. In others, hospital ships, which have proved extremely useful with their multipurpose adaptabilities, especially in amphibious and insular operations, are employed for this procedure. In still others, air-transports are used and have played an important role in the rapid evacuation of wounded from relatively inaccessible areas in which other transportation facilities are limited and travel is arduous.

The general hospitals that receive these patients are located well behind the line of combat and under relatively more stable conditions. They are comparatively large installations of 1000 beds or more possessing all the equipment and facilities for the institution of the best and most highly specialized surgical care. Many of these hospitals are comprised of affiliated units completely staffed from the ranks of medical school faculties and representing the most talented and experienced men of the profession. The extraordinary liberality and the cheerful contribution of the medical schools of this country in re-establishing these general hospitals deserve the highest commendation. The function of these general hospitals in the care of the wounded may be considered twofold; to apply further and more definitive surgical treatment which would permit the patient to return to duty within a period of a few months or, if the soldier's injury precludes his return to duty or will require prolonged hospitalization, to prepare the patient for evacuation to this country. Definitive surgery performed at these hospitals included all specialties and their high level of professional performance is demonstrated by the steadily increasing numbers of wounded that are being returned to duty. Many of these patients are sent from general hospitals to convalescent centers where they are reconditioned for combat duty. Patients whose injuries make them unfit for further military service and all those who will require further definitive treatment and more than four to six months' hospitalization are evacuated by hospital ships and transports to the general hospitals here at home as soon as they can be made transportable.

The wounded évacués arrive at ports of debarkation and are received at near-by general hospitals where an assessment of their general condition and type of injury is made and necessary supportive measures applied. The patients are then classified according to the character of the injury and sent in hospital trains to general hospitals in the interior.

The Army Medical Department now has forty-eight of these general hospitals in operation and provisions for eleven more. They are all completely equipped with the most modern facilities and staffed by highly competent physicians, representing all the specialized fields of medicine and surgery. In addition, a number of these hospitals have been designated as specialized centers for the treatment of patients with certain conditions in which a high degree of specialization is necessary. Thus, at the present there are five centers for chest surgery, five for plastic and ophthalmologic surgery, five for amputations, sixteen for neurosurgery, two for vascular surgery, and two each for the rehabilitation of the blind and the deaf. These highly specialized centers are strategically located and in so far as possible, patients are sent to the appropriate hospital nearest their home. This program of the final phases of definitive surgical care of the wounded is directed toward the physical rehabilitation as well as the psychological reconditioning of war casualties so that the maximum number may be salvaged and permitted to resume a useful place in industry and society.

## THE PLASTIC REPAIR OF SCAR CONTRACTURES

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A CONTRACTURE may be defined as a pathologic shortening that results from pull of a scar which is secondary to a cutaneous loss. By far the greater majority of contractures result from skin defects that follow improperly managed third degree burns. Likewise, if cutaneous loss after a large avulsion is not covered early with a skin graft, the scar resulting from the closure of the wound by secondary intention may contract in the same manner as that following third degree burns. Improperly sutured lacerated wounds may produce similar complications. The harmful scars which create these conditions are found chiefly around kinetic areas such as the eyelids, mouth, neck, axillae, and the extremities.

### PREVENTION

The prevention of scar contractures as with any other disease, of course, is most desirable. The early covering of cutaneous defects following third degree burns with a properly selected type of skin graft is the ideal procedure. Moreover, replacement or skin grafting of avulsions should always be carried out as soon as the patient's condition will permit. Lacerated wounds should be closed with care and thought. Linear lacerations on flexor surfaces such as the fingers may tend to develop contractures after healing occurs due to the straight line scar. This often can be obviated by the construction of one or more Z flaps (Figs. 1 and 2) at the time of primary closure, thus producing a staggered instead of a straight scar. It is futile to attempt to prevent scar contractures by traction or splinting in either the early or late stages unless provision is made to eliminate the offending scar. Temporary improvement might be obtained but owing to the fact that all scar tissue tends to contract, the extended parts will promptly revert to their original malposition as soon as the traction or splinting is removed.

### TREATMENT OF HEALED SCAR CONTRACTURES

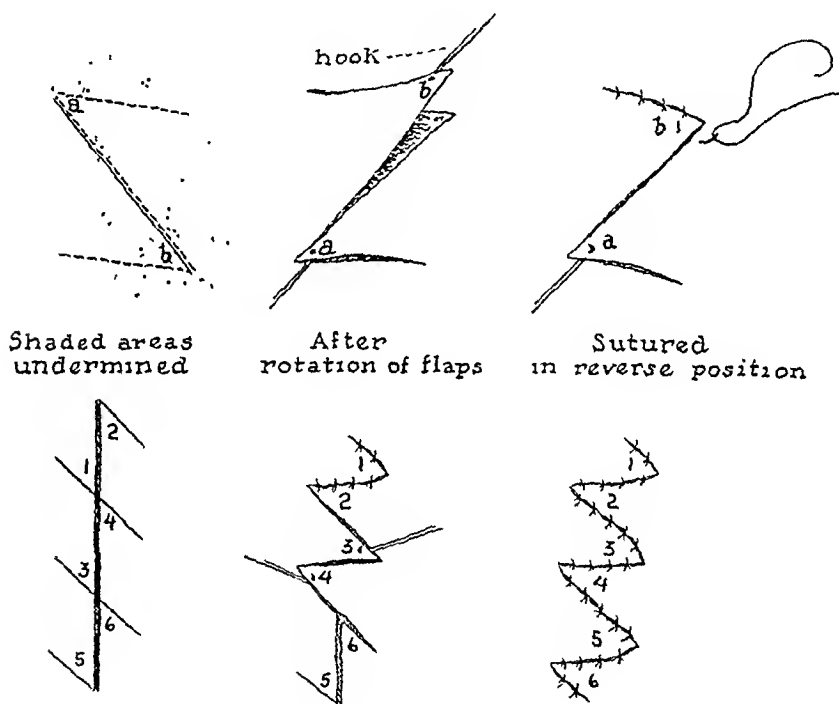
The treatment of healed contractures first involves the excision of all contracting scar tissue following which the remaining parts are returned to their normal anatomic position. The cutaneous defect that results from this maneuver is always much larger than the size of the scar



excised. One never ceases to be amazed at the size of the real dimension of the actual defect after it has been properly prepared by removal of all contracting scar tissue.

Once the cicatrix has been excised, the contracted part is extended and hemostasis controlled. The surgeon is then confronted with the problem of covering the resulting cutaneous loss. The actual method of closure for any such defect is based upon fundamental principles plus some imagination and ingenuity on the part of the operator in dealing with the particular problem at hand.

### Z - PLASTIC



### MULTIPLE - Z - PLASTIES

FIG. 1.

There has been considerable effort expended on the part of some plastic surgeons during recent years to close defects of this type by simpler and less cumbersome methods. Complicated pedicle flaps of skin have been supplanted to a large extent by some kind of free graft or by the use of Z plasties and interpolated flaps whenever such procedures can be utilized.

In selecting the proper type of skin graft to use one must keep in mind the comfort and safety of his patient, the economic problem involved, and the final functional and cosmetic result desired. Since the

use of pinch and Thiersch grafts give rise to much subsequent scarring, the contracture may recur. Free full-thickness skin grafts may be the most difficult to grow, but will give the best functional results, especially

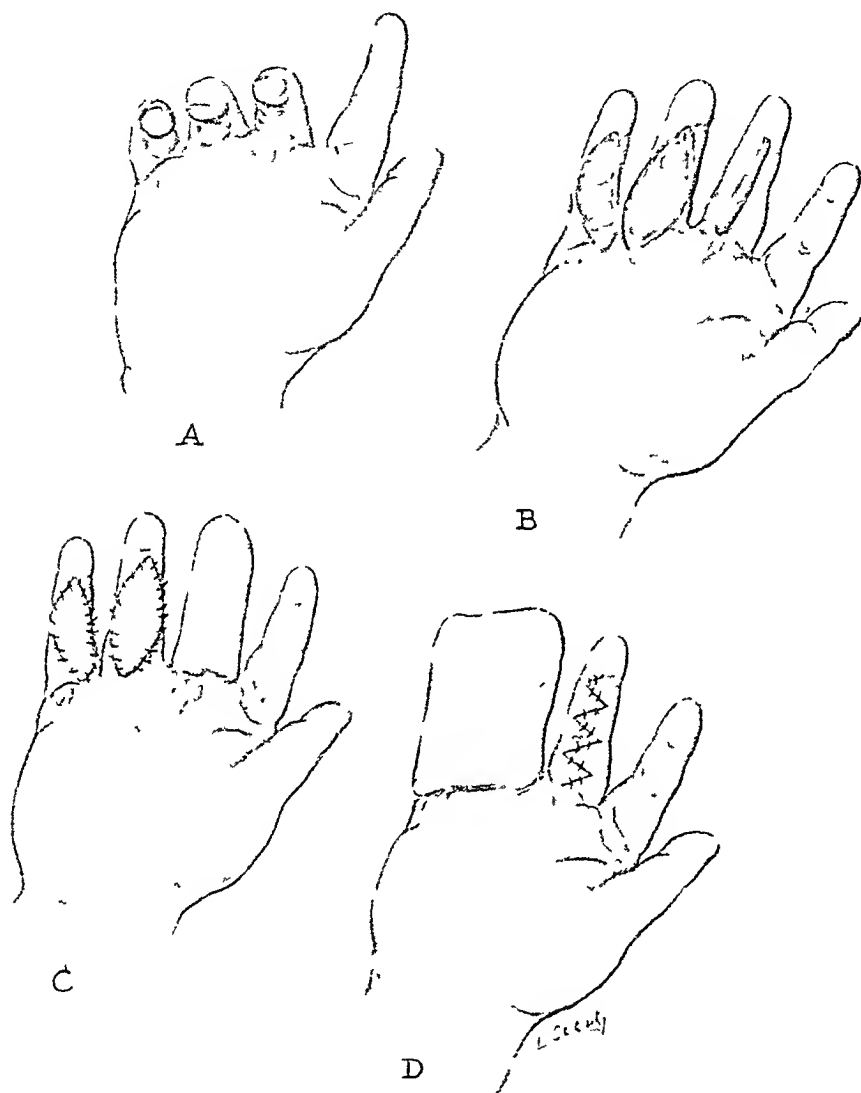


Fig. 2 (Case 9).—Drawing A shows scar contractures involving middle, ring, and little fingers. B demonstrates actual skin loss after excision of scars and extension of fingers. It is our practice in such defects to extend the incision laterally on each side producing a diamond-shaped defect. This staggers the subsequent suture line between normal skin and the graft, thereby eliminating potential recurrence of the contracture along newly created suture lines. In this case, C shows the ring and little fingers covered with free full thickness grafts, while D demonstrates how it was possible to close the smaller defect in the middle finger with a triple Z plasty.

when dealing with smaller structures such as fingers. For large defects resulting from the removal of extensive contractures of the neck, elbow, axillae, and popliteal space, we have been successful in the majority of our cases following the utilization of single massive thick split-thickness

skin grafts. These are cut in single pieces large enough to cover the defect. Being cut in these large sizes there has been a minimum amount of postoperative contraction or fibrosis. Furthermore, the donor sites heal spontaneously, the certainty of take is maximum, and the economical aspect of the patient considerably simplified.

The use of tube pedicle flaps in our experience has been reserved chiefly for those conditions needing a skin covering to which is attached a subcutaneous fat pad and for those in which such a flap could not be rotated to cover a defect from an area immediately adjacent.

We have been much impressed by the wider range of use of Z-plastic procedures as more recently popularized by Ferris Smith and Davis and Kitlowski. Many defects that have fairly mobile lateral skin flaps can be closed by this method (Fig. 1). Not only is an excellent covering available, but the area may be closed in one relatively simple procedure. By utilizing a certain amount of imagination the final scar can be so staggered that no contracture will result following complete organization of the suture line.

#### COMPLICATIONS

Wishful hoping will never correct a scar contracture. If these conditions are permitted to go untreated in growing children, the unyielding cicatrix will cause the formation of many underlying bony maldevelopments that may never be corrected. In addition, the functional disturbance will be accentuated, and also the cosmetic deformity will likewise be aggravated. These conditions may contribute much to the future psychologic and economic failure of the patient.

Owing to the constant pull in some cases frequently the contracting scar may break down and become the site of a chronic ulcer. Not only is this open wound a constant source of annoyance to the patient but it is a fertile field in which secondary malignant changes may develop (Fig. 14).

#### ILLUSTRATIVE CASES

CASE 1.—An 18-year-old girl was admitted two years after a third degree burn was sustained when she fell against a stove. The scar which developed not only produced a marked facial disfigurement but ectropion of the lower eyelid as well (Fig. 3). The scar was excised completely and the resulting defect covered with a single free full-thickness skin graft taken from the hairless inner aspect of her upper arm. A small degree of ectropion persisted after this operation. Six months later, after the first graft had softened, another small Wolfe graft taken from the upper eyelid was inserted and the remaining downward pull relieved. The missing middle third of the eyebrow was replaced by a hair-bearing free full-thickness graft from the scalp.

CASE 2.—This man received a flaplike laceration of skin a little over one inch square involving his right eyebrow and the area immediately above. He was taken

to a physician who cleansed the wound and sutured it in place following which a loose dressing was applied. Within twenty-four hours the flap became gangrenous and when referred to us was further complicated by considerable infection. At this stage it was necessary to remove the necrotic tissue and permit the wound to fill in by secondary intention. Had the original surgeon applied pressure to the avulsed flap and treated it like a piece of grafted skin, it would have undoubtedly grown in toto.

As a result of the large skin loss, an ectropion of the upper lid resulted from the pull of the forehead scar (Fig. 4). It was necessary to remove the scar and replace the defect with a free full-thickness skin graft. We next plan to construct a new eyebrow by utilizing a free hair-bearing graft from the scalp.



A.

B.

Fig. 3.—Case 1.

CASE 3.—The late results of an extensive third degree burn are well illustrated in this patient. She was first seen by us nearly two years after her injury. There is an extensive contracture of the neck and both axillae (Fig. 5).

Since the neck contracture was causing the patient the most discomfort, we first excised the contracting scar and covered the resulting defect with one large single thick split-skin graft.

At a later date, one axillary contracture was excised and replaced with a single thick split skin graft. Two weeks later as soon as this was healed the opposite side was managed in a similar manner.

CASE 4.—As a small child this young lady suffered a third degree burn of her neck. A burn contracture resulted and was first operated upon elsewhere. The surgeon apparently excised the scar and covered the defect with Thiersch grafts. As might be expected, much fibrosis developed and when we first saw her, a great deal of deformity still remained (Fig. 6).

Upon examination it was noted that most of the subcutaneous fat had been destroyed. In fact, the larynx was uncomfortably embedded in the scar. In view of these findings, we elected to cover the anterior portion of the neck with a pedicle flap containing a good subcutaneous fat pad. This was done by turning a tube pedicle graft forward from the upper portion of the back. While a good functional result has been obtained, we must admit that it is not cosmetically ideal.



A.

B.

Fig. 4.—Case 2.

CASE 5.—A five-year-old child had a linear scar contracture of the neck that was pulling down the corner of the mandible and mouth (Fig. 7). We excised this scar, constructed two large Z flaps, and reversed the line of pull with a very good result. This was accomplished in one operation with but five days' hospitalization.

CASE 6.—This 16-year-old girl had a broad scar on her neck that resulted from a third degree burn in childhood. It did not produce as much contraction as it did cosmetic deformity (Fig. 8). We managed this by the method of multiple excision. In two larger operations, four months apart, the bulk of the scar was excised and the wound closed by suture after wide undermining. At a third minor operation we revised the suture line. There is now but one small linear scar on the side of the neck that is cosmetically quite inconspicuous.



Fig. 5A.—Case 3, preoperative views of patient.

CASE 7.—The 5-year-old girl presented here had an extensive axillary contracture following a third degree burn at the age of two (Fig. 9). In one operation, we removed the contracting scar, abducted the shoulder, and covered the resulting cutaneous defect with one single thick split-skin graft.

CASE 8.—The patient illustrated here (Fig. 10) presents a slightly different variety of axillary contracture than demonstrated in the foregoing cases. It will be noted that there is a broad web of skin that stretches across the anterior axillary

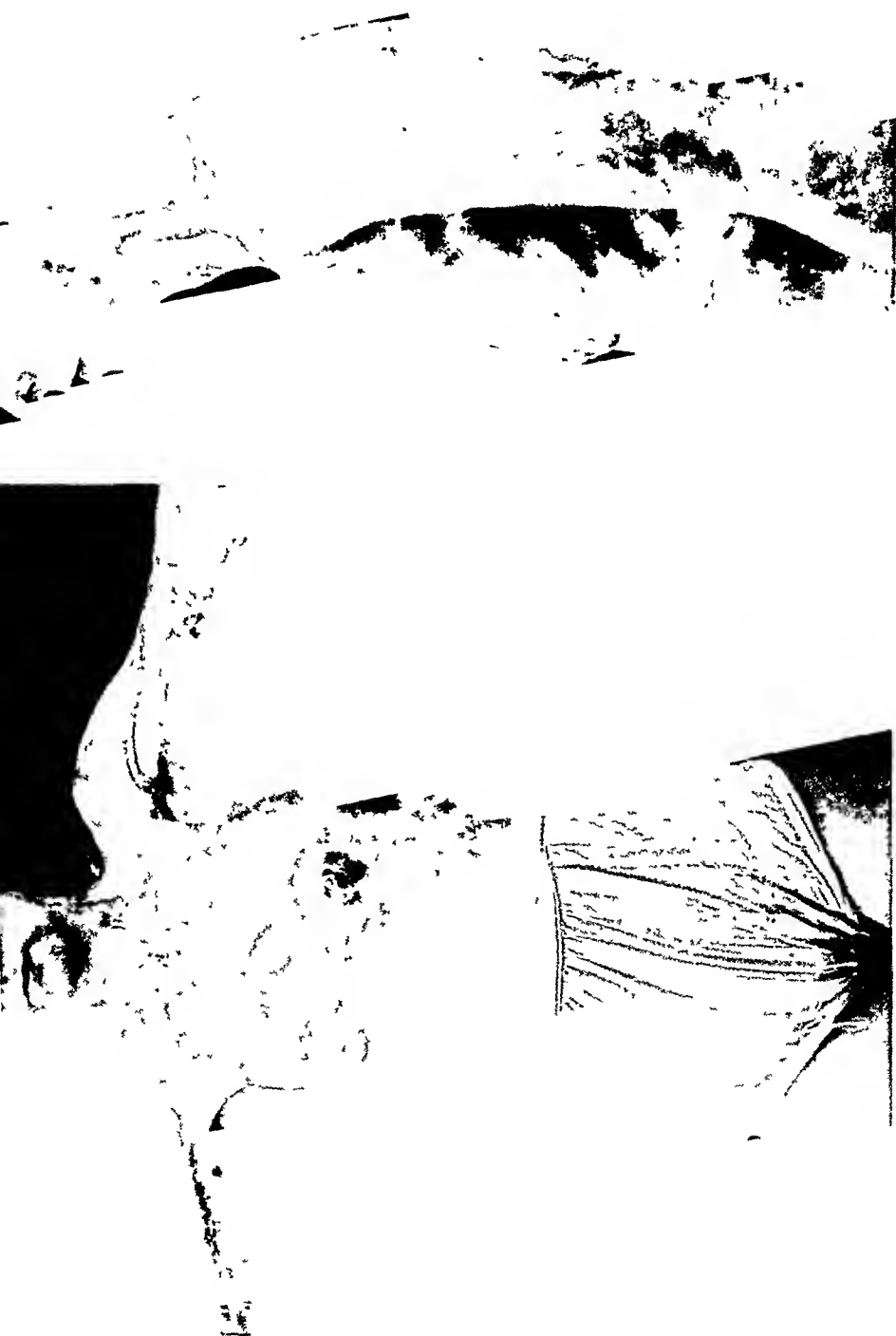


FIG 5R—Case 3.

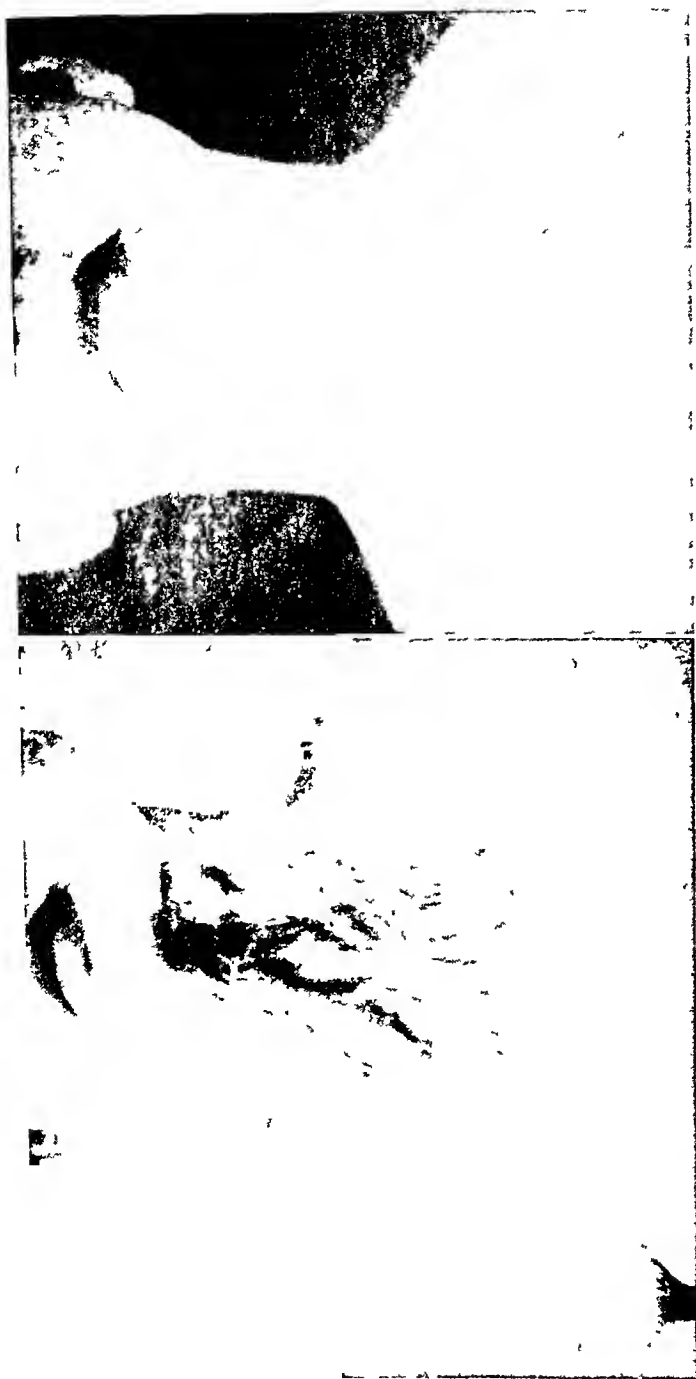


Fig 6—Case 4.





A.

B.

Fig. 7—Case 5.



Fig. 8A—Case 6

Fig. 8B.—Case 6.



A.

Fig. 9.—Case 7.

B.



Fig. 10A.—Case 8.

fold. This made available two large flaps of skin so that the contracture could be relieved by a Z plasty. At the same operation the elbow contracture was excised and a single large thick split-skin graft applied. All of these procedures necessitated only nine days' hospitalization. (This is a recent case.)



Fig. 10B.—Case 8.

CASE 9.—A 4-year-old girl suffered third degree burns of the middle, ring, and little fingers three years before treatment. Two years previously the contracting scars were excised elsewhere, following which the wounds were simply sutured lengthwise. As soon as the scars healed, they promptly contracted back to their original deformity (Fig. 2), in spite of prolonged postoperative splinting in extension.

We reexcised the scars and replaced the defects of the ring and small fingers with free full-thickness skin grafts so that the maximum degree of elasticity of the

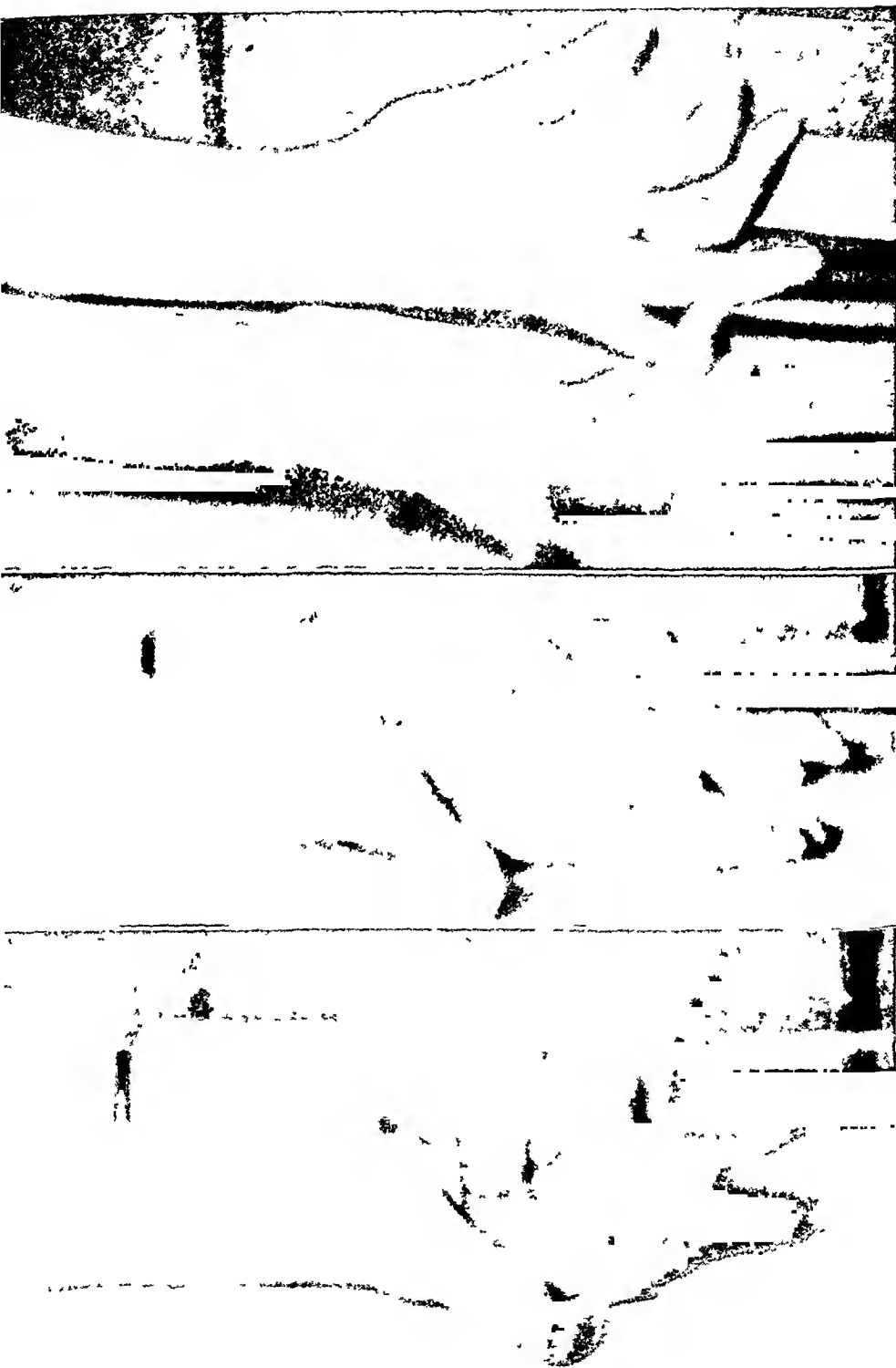
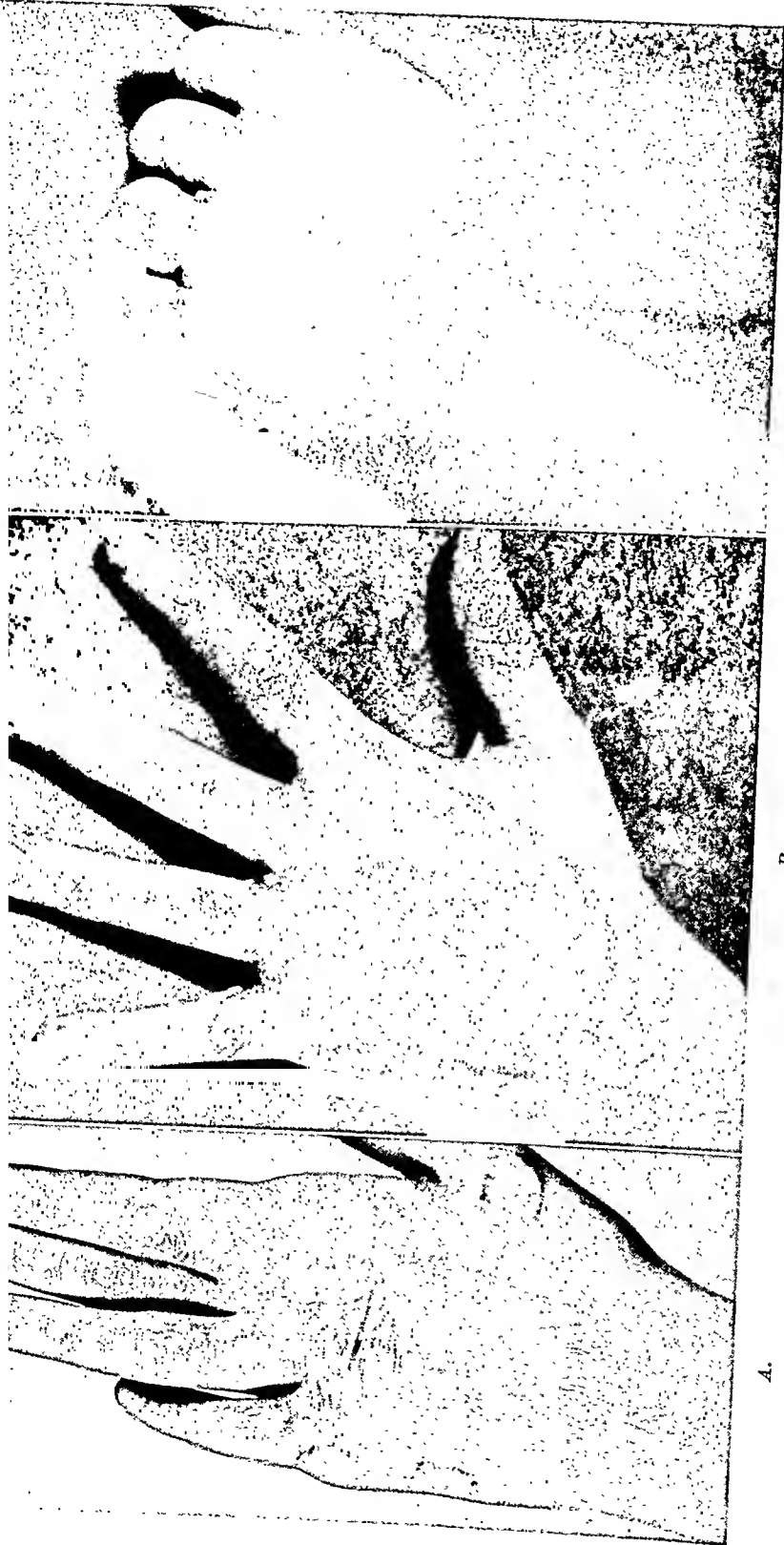


Fig. 11.—Case 10.



C.

B.

A.

Fig. 12.—Case 11.

an extension contracture developed within six months after the original injury (Fig. 12).

We corrected this deformity by first excising the contracting scar over the dorsum of the hand and extending distally over the bases of the extensor surfaces of the fingers. The cutaneous defect that followed was covered with one single thick split-skin graft. At a later date the interdigital webs were split and deepened by Z plastic procedures.

CASE 12.—Here we have a 26-year-old man who developed a contracting scar following a third degree burn during childhood that completely encircled his leg just below the knee (Fig. 13). The scar would frequently break down and ulcerate. The contraction not only caused limitation of his knee joint but also considerable swelling of the leg below.

We completely relieved the condition by excising the scar thoroughly and permitting the adjacent soft parts to retract back to their normal positions. One single thick split-skin graft was then applied so as to completely encircle the leg.

CASE 13.—Much has been said regarding the late malignant complications that develop in untreated burn ulcers but few cases are actually seen reported in the literature.

Here (Fig. 14) we have a 70-year-old man who had suffered an extensive third degree burn of his thigh and groin fifty years previously. After one year the area had filled in with a thick fibrotic scar that would break down frequently and ulcerate. Three years before admission to our service a tumor developed in the area of ulceration which, when we first saw it, was gangrenous, infected, and very foul smelling.

We first excised the lesion widely, using the diathermy cutting current. After clean granulations had developed in three weeks, we covered the defect with two large thick split-skin grafts. We probably erred in not excising the inguinal and femoral lymph glands at the first operation since eighteen months later he had a small local recurrence in the groin. We reoperated, excising all glands, and after more granulations had formed, the defect was covered with another smaller thick split-skin graft. The leg remains healed at this time, two years after the first operation. Sections showed the tumor to be an epidermoid carcinoma.

Note: The chronic recurring ulcer in Case 12 is the logical forerunner of a later malignant degeneration.

#### CONCLUSIONS

1. Scar contractures can be relieved by first excising all shortened fibrotic tissue, following which the parts are extended into normal anatomic position. The resulting cutaneous defects are then closed by the use of a Z-plastic procedure or the utilization of a properly selected type of skin graft.

2. Scar contractures may be prevented by the early skin covering of granulating defects resulting from burns or avulsions of skin. Careful planning in the suture of lacerations may likewise avoid the development of contractures if the line is closed in a staggered axis.

3. All contractures in growing children should be corrected before permanent underlying bony maldevelopments occur. Moreover, chronic ulcerations occurring in certain contractures should be repaired promptly for fear of secondary malignant changes.

## REFERENCES

1. Smith, Ferris: J. A. M. A. 120: 5, 352, 1942.
2. Davis, J. S., and Kitlowski, E. A.: Ann. Surg. 109: 1001, 1939.
3. Morestin, H., Bull. et mém. Soc. de chir. de Par. 41: 1233, 1915.
4. Mac Collum, Donald W.: J. A. M. A. 116: 2371, 1941.
5. Mac Collum, Donald W.: Am. J. Surg. 39: No. 2, 275, 1938.
6. Kazanjian, V. H.: New England J. Med. 215: 24, 1104, 1936.
7. Coughlin, W. T.: Surg., Gynec. & Obst. 68: 352, 1939.
8. Greeley, Paul W.: Illinois M. J. 75: 436-441, 1939.
9. Greeley, Paul W.: S. Clin. North America 22: 1, 253, 1942.
10. Young, Forrest: Surg., Gynec. & Obst. 67: 73, 1938.
11. Gillies, H. D.: Am. J. Surg. 43: No. 2, 201, 1939.

# EPITHELIZATION AS AFFECTED BY NICKEL PECTINATE AND OTHER AGENTS

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## INTRODUCTION

THE evolution of the pectin and nickel pectinate treatment for dysentery and infant diarrhea is described by Block and associates.<sup>1</sup> Haynes and co-workers<sup>2</sup> and Arnold<sup>3</sup> discovered that pectin alone actually stimulated bacterial growth, but that the pectinates of certain metals, nickel included, was slowly bactericidal. Myers and Rouse<sup>4</sup> pointed out that ionized nickel is toxic to bacteria and in addition that the catalyst, nickel, may stimulate the body's antitoxin and agglutinin production. Other qualities of nickel pectinate doubtless contribute to its effectiveness as a vulnerary. The huge pectin molecule may, theoretically at least, envelope and starve bacteria.<sup>5</sup> Pectin is a hygroscopic colloid, able to absorb many times its weight,<sup>6</sup> thus stimulating the "osmotic drainage" effect and reversal of lymph flow claimed by Smith<sup>7</sup> and others for glycerin. Lastly, upon hydrolysis, pectin liberates galacturonic acid, an isomer of glycuronic acid that the liver synthesizes as a chemical detoxifying agent.<sup>4</sup>

Thomson,<sup>5</sup> in 1938, reported favorable results in the use of aqueous solutions of pectin in treating burn granulations, chronic osteomyelitis, and infected wounds in general.

Since latter 1938, we have treated a variety of wounds with a preparation of nickel pectinate\* containing 3 per cent pectin and 0.045 per cent nickel, either in aqueous solution or in tragacanth jelly. Merthiolate, 1:5000, was added to inhibit growth of fungi. In the great majority of cases the tragacanth vehicle was used since the thick jelly required but one application a day, an important factor in this understaffed hospital. After the toilette of the wound, the jelly was applied to a depth of 3 to 5 mm., with a sterile throat stick. From here, technique varied. Over some wounds, especially if drainage were profuse, the outer dressing consisted merely of several layers of sterile gauze and an outer pad of cellucotton held in place by adhesive or bandage. In other cases, a layer of perforated cellophane was interposed between the agent and the outer dressings in order to retain moisture. In a few extensive burns with pin-point grafts in place, a generous buttering of the nickel pectinate

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\*This has been supplied to us by Eli Lilly and Company under the name of "Nipectin."



was left without any outer dressings. Especial care was taken in removal of dressings, as the pectin jelly was prone to become tightly adherent to the wound surface. In such cases, removal was usually accomplished by soaking or by pouring on hydrogen peroxide.

During the past 4 years, 65 wounds in 61 patients have been treated with nickel pectinate. As a control in this same period, comparable wounds or comparable portions of the larger wounds were dressed with cod liver oil or cod liver oil ointment. In rare instances the control agent was Dakin's solution, Foille,\* sulfonamide ointment, or scarlet red. Also, similar bilateral wounds were likewise treated in 6 rabbits. I followed and supervised the course in all these cases.

#### CLINICAL APPLICATIONS

*The Use of Nickel Pectinate in Sluggish Wounds That Have Responded Poorly or not at all to Other Agents.*—Seven stubborn cases are presented in brief. In 4 cases (Patients 1, 2, 6, and 7 below), pectin seemed definitely superior to the alternate agents; in 2 cases (Patients 3 and 5), it seemed about equally effective; and in one case (Patient 4 with the ventral hernia with superficial erosions), all agents, pectin included, failed to close the erosions.

1. PATIENT N. M.—Lesion: Infected Thiersch graft donor site of left thigh. The lower left leg was completely decorticated down to the muscles as a result of extensive incisions for gas gangrene some time before. For 106 days the shallow ulcerations on the thigh were unsuccessfully treated with saline packs, Dakin's packs, gentian violet, ammoniated mercury ointment, and ultraviolet irradiations. There were still two granulating areas 2 by 3 cm. and several pustules 0.5 cm. in diameter. Culture: *Staphylococcus aureus*. Healing occurred after 60 days of nickel pectin dressings.

2. PATIENT J. K.—Lesion: Fire burn of neck and upper chest resolving into two granulating wounds each about 2½ cm. in diameter, one over each sternoclavicular articulation. Culture: *Staph. aureus*. By the fortieth day, progress on foille dressings was at a standstill and nickel pectinate jelly was started. At this time the lesions were approximately 2½ by 2 cm. and 1½ by ½ cm. in area, respectively. Healing was complete in 20 days.

3. PATIENT R. H.—Lesion: Granulating scalp avulsion wound. After pin-point grafting and 65 days of cod liver oil dressings, several nonepithelized areas remained, the largest 2 by 2 cm. Culture: *Bacillus pyocyaneus*. Nickel pectinate dressings were started and at first healing was rapid. Final healing, however, required 55 days.

4. PATIENT L. W.—Lesion: Shallow erosions, 1 to 2 cm. in diameter on the convexity of a huge ventral hernia. After 155 days of treatment with elastoplast, cod liver oil, and other remedies, there was no sign of healing. Culture: *Staph. aureus*. However, although definitely smaller, there was no healing after 40 days of nickel pectin therapy.

5. PATIENT B. A.—Lesion: Granulating pinch-grafted burn of left axilla 6.5 by 2.5 cm. in area. The lesion was slowly enlarging after 55 days of cod liver oil

\*"Foille" is a proprietary water-in-oil emulsion for the treatment of burns.

TABLE I

ANALYSIS OF 18 SUPERFICIAL GRANULATING WOUNDS TREATED IN COMPARABLE HEALING WITH NICOTIN PLACINYL AND WITH CONTROL AGENTS

PA- IENT	AGE (YR.)	INJURY	AGENTS	REMARKS	DAYS UNTIL HEALED
L. S.	23	Granulating postburn wound of entire right upper arm, external aspect. Punch grafted 8 days before with 90% take throughout. Culture both halves: <i>Strep. hemolyticus</i> , <i>Staph. aureus</i> .	N.P. * upper half T.O. lower half	Neither area had the advantage toward healing. The N.P. area healed in 31 days, then broke down for 41 days. This was added to its total healing time.	N.P., 72 T.O., 97
D. P.	35	Superficial granulating excision site of neurofibroma of epigastrium 13 by 10 cm. Punch grafted 9 days before. Culture: <i>Strep. hemolyticus</i> , later, <i>Staph. aureus</i> .	N.P. right half C.L.O. left half	Neither side had the advantage toward healing; granulations markedly lower on N.P. side than on control side.	N.P., 23 C.L.O., 41
L. G.	12	Granulating postburn wound of back of lower thigh and popliteal area 15 by 11½ cm in area. Punch grafted 12 days before. Culture: <i>Strep. hemolyticus</i> , <i>Staph. aureus</i> .	N.P. upper half C.L.O. lower half	There were slightly fewer grafts on postburn area and this area also included the flexure crease.	N.P., 26 C.L.O., 26
V. M.	18	Granulating postburn wounds similarly involving backs of both thighs and calves. Punch grafted 78 days before; slow healing. Culture: both sides, nonhemolytic strep; <i>Staph. aureus</i> .	N.P. right side T.O. left side	Neither side had the advantage toward healing. N.P. side had already been on C.L.O. dressings without success 78 days.	N.P., 39 T.O., 55
D. B.	5	Granulating postburn wound of back of thigh, calf, and popliteal area, 15½ by 7 cm. Punch grafted 15 days before with 75% take. Culture: <i>Staph. aureus</i> .	N.P. proximal C.L.O. distal half	Neither side had the advantage toward healing. There was marked granulation tissue hyperplasia on C.L.O. side; healing delayed both sides by intercurrent hemolytic strep.	N.P., 41 C.L.O., 15
N. L.	63	Postmastectomy granulating wound 26 by 7 cm. Punch grafted 5 days before. Culture: <i>Staph. aureus</i> , <i>B. proteus</i> .	N.P. lateral half C.L.O. medial half	Although there was more tension on the N.P. dressed end, overlying the axillary fold, it was slightly narrower and had an extra pinch graft on two.	N.P., 23 C.L.O., 37+
B. M.	7	Granulating postburn wounds of lower back and thighs, 2 in each area measuring 8 by 3 cm approximately. Punch grafted 7 days before. Culture: <i>Strep. hemolyticus</i> , <i>Staph. aureus</i> .	N.P. areas on back C.L.O. areas on thighs	Neither side had the advantage toward healing.	N.P., 17 C.L.O., 65
I. R.	38	Granulating postburn wound of most of right lower leg. Punch grafted 7 days before. Culture: <i>Strep. hemolyticus</i> , <i>Staph. aureus</i> .	N.P. medial half C.L.O. lateral half	The C.L.O. dressed area had a slight advantage toward healing and these dressings were less painful.	N.P., 27 C.L.O., 15
A. P.	66	Two granulating varicose ulcers of leg, one 9 by 5 cm, the other 9 by 3 cm. Both punch grafted 4 days before. Culture: N.P. side, <i>B. pyocyaneus</i> , C.L.O. side, <i>B. pyocyaneus</i> , <i>B. proteus</i> , <i>Staph. aureus</i> .	N.P. on area 9 by 5 cm C.L.O. on area 9 by 3 cm.	Neither side had the advantage toward healing; strikingly less granulation tissue hyperplasia on N.P. side.	N.P., 26 C.L.O., 47

\*N.P.—nicotinic postburn

†C.L.O.—cod liver oil

B. R.	64	Long granulating, superficial postincision and drainage wound of forearm, 33 by 5 cm. Pinch grafted 11 days before with 90% take. Culture: <i>Staph. aureus</i>	N.P. distal half C.L.O. proximal half	N.P. area had slight advantage toward healing, being narrower with slightly more grafts; rate of healing much faster	N.P., 7 C.L.O., 14
S. L.	58	Granulating postburn wound of left thigh and buttock. Pinch grafted 22 days before with 65% take. Culture: N.P. side, <i>Staph. aureus</i> and <i>B. proteus</i> , C.L.O. side same and <i>B. pyocyaneus</i>	N.P. on buttock C.L.O. on thigh	Slightly fewer grafts per unit area on dressed area	N.P. 38 C.L.O., 43
A. G.	16	Granulating postburn wounds of both ears involving rims of auricles, each measuring 30 by 3 mm. No grafts. Culture: <i>Staph. aureus</i>	N.P. right ear Sulfadiazine ointment left ear	The two areas nearly identical; healing was delayed on N.P.-side by trauma of removing tightly adhering dressing	N.P., 16 Sulfa., 13
N. B.	3	Granulating postburn wounds back and right upper arm, former 9½ by 4 cm., latter 5½ by 4½ cm. Pinch grafted 7 days before. Culture: <i>Staph. aureus</i>	N.P. on back C.L.O. on arm	There were a few more grafts on the C.L.O. area; granulation tissue hypertrophy only on C.L.O. area.	N.P., 53 C.L.O., 65
N. B.	3	Granulating site of superficial tissue slough, right lower leg 10 by 4 cm. Pinch grafted 13 days before with poor take. Culture: <i>Staph. aureus</i>	N.P. proximal half C.L.O. distal half	Neither side had the advantage toward healing; progress slow; granulation tissue hyperplasia both sides	N.P., 63 C.L.O., 58
W. S.	39	Identical granulating postburn wounds on inside of right and left thighs; right 14 by 13 cm., left 15 by 6 cm. Pinch grafted 9 days before with 95% take. Culture: both sides, <i>Staph. aureus</i>	N.P. right side Foille left side	Neither side had the advantage toward healing; due to granulation tissue stimulation folle was changed to C.L.O.	N.P., 15 C.L.O., 15
H. R.	13	Granulating, full thickness by skin donor site of chest and upper abdomen 16 by 13 cm. Pinch grafted 5 days before with 90% take. Culture: <i>Staph. aureus</i>	N.P. lower half C.L.O. upper half	Neither side had the advantage toward healing. Progress was more rapid with N.P.; patient away from observation at final healing	N.P., 28 C.L.O., 28
W. D.	30	Granulating postburn wound of lower back, 13 by 7 cm. Pinch grafted 6 days before with good take. Culture: N.P. side, <i>Staph. aureus</i> , <i>B. pyocyaneus</i> , C.L.O. side, <i>Staph. aureus</i>	N.P. right side C.L.O. and sulfadiazine on left side	Neither side had the advantage toward healing; granulation tissue hyperplasia only on control side; sulfadiazine replaced	N.P., 63 Sulfa., 80+
G. T. (See Fig. 3)	13	Granulating postburn wound of entire chest, bilaterally identical. Pinch grafted 7 days before with 60% take. Culture: <i>Staph. aureus</i> , <i>pyocyaneus</i> , <i>B. proteus</i>	N.P. left side C.L.O. right side	Neither side had the advantage toward healing; amazing rapidity of epithelization on N.P. side; practically healed by 25th day. The last tiny areas were very slow in healing and repeatedly broke down	N.P., 103 C.L.O., 103

dressings. Culture: *Streptococcus hemolyticus* and *Staph. aureus*. There was progress on nickel pectinate regime to almost complete healing in 30 days. There was then a period of regression and final healing required 54 more days.

6. PATIENT N. S.—Lesion: Granulating burns of backs of both thighs that had been pinch-grafted 140 days previously. For 134 days Dakin's packs and gentian violet had been applied, but there still remained several pustules and a granulating patch 5 by 4 cm. in area. Culture: *Staph. aureus*. Healing occurred after 35 days of pectin therapy.

7. PATIENT F. L.—Lesion: Granulating areas in right orbit following evisceration operation for basal-cell epithelioma. Pinch grafts had been applied 135 days before. After 111 days of vaseline gauze and gentian violet treatment, the granulating areas were not reduced in size. Healing was complete after 21 days of nickel pectinate dressings.

*The Use of Nickel Pectinate on Superficial Granulating Wounds.*—The majority of these were granulating postburn wounds, but also included were denuded areas following radical mastectomy, excision of tumors, extensive incision and drainages, etc. Treatment was instituted shortly after the placing of pin-point grafts, and continued until final healing. Occasional cases that could not be reasonably kept on the ward until healing were followed for the final days in the outpatient department.

There were 40 of these wounds suitable for a comparison in rate of epithelization between nickel pectinate and control agents. Cod liver oil or cod liver oil ointment served as a control in all but 5 cases. In these 5 cases, foille was used three times and a 5 per cent sulfonamide ointment was used twice.

Eighteen of the larger wounds that were nearly uniform throughout were divided for treatment into two nearly identical halves, one half being dressed with nickel pectinate, the other with the control agent. These cases were outlined in Table I. As shown in Table II, the aver-

TABLE II

COMPARATIVE HEALING TIMES OF NICKEL PECTINATE TREATED AND CONTROL TREATED WOUNDS

AGENT USED	LARGE WOUNDS TREATED IN COM- PARABLE HALVES WITH NICKEL PECTINATE AND WITH CONTROL		WOUNDS TREATED WITH ONE AGENT ONLY		COMBINED	
	NUMBER	AVERAGE DAYS UN- TIL EACH HALF HEALED	NUMBER	AVERAGE DAYS UNTIL HEALED	NUMBER	AVERAGE DAYS UNTIL HEALED
Pectin	17*	35.7	15	24.2	32	30.3
Control (C.L.O. in all but 5 cases)	17*	43.8	7	26.7	24	38.8

\*Case G. T. (See Table I) was not included here since his unduly prolonged healing time of 120 days should not fairly be included with the remaining 17 cases.

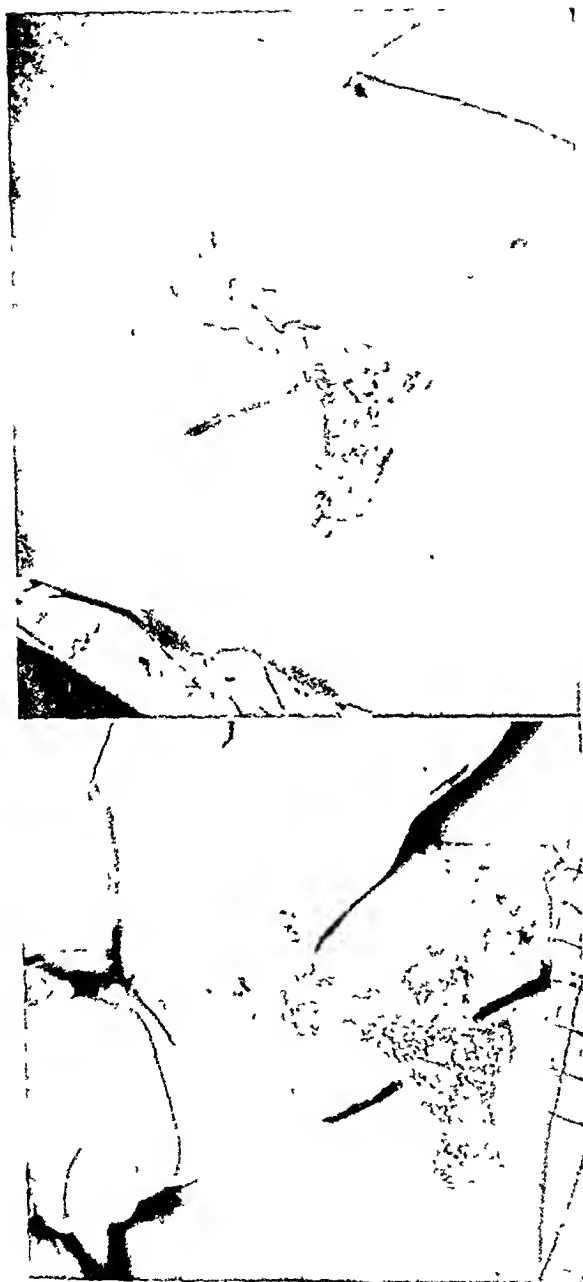
age healing time for the nipectin-treated half of the wounds was 35.7 days, for the control-treated, 43.8 days, or 22 per cent longer. In Table II is also compared the healing times of the other 22 miscellaneous superficial wounds, 15 dressed with nickel pectin, the remaining 7 with a control agent, usually cod liver oil.



FIG. 1.—A, Patient L. S. at start, 8 days after pinch grafting. Upper half, above arrows, dressed with nickel pectinate jelly. Lower half, apparently identical, dressed with foile. B, Same patient 24 days later. Pectinate area practically healed. Note sharp transition between experimental and control areas produced by epithelization of pectin side.

Almost as striking as the reduction of epithelization time in these cases was the contrast in appearance between the two sides of the wound. The granulations on the nipectin side almost invariably remained smooth, flat, and rather pale, whereas on the control side they were rosy, hypertrophied, and bled easily. In case G.T. (see Table I and Fig. 3) when the nipectin side was nearly completely epithelized, there were granulations on the cod liver oil ointment side 9 mm. high! The healed pectin-dressed wound differs little from one that has received some other type of treatment. If anything, the skin in the former is smoother and more stable.

*The Use of Nickel Pectinate in Deeper Wounds.*—Noting the remarkable tendency of nickel pectinate in depressing granulation tissue over-



4.

B.

Fig. 2—4, Patient S. L. at start, 5 days after pinch grafting. Lower half, nearly identical, dressed with cod liver oil. B, Same patient 15 days later. Pectinate area nearly healed. Granulation tissue hyperplasia on cod liver oil side

growth, we tested its effect in 5 comparatively deep infected wounds. Four of these were infected laparotomy wounds, the fifth an infected wound following a bilateral inguinal dissection for carcinoma of the penis. In 3 of these wounds (see Figs. 4, 5, and 6) the same control system already described was employed, namely dressing one half with nickel pectin jelly, the other half with cod liver oil or ointment. In from 7 to 10 days a remarkable difference was apparent between the nickel pectinate and the control side. The pectin granulations were pale, low, and smooth, those on the control side were rosy, exuberant, and much higher than on the experimental side. Biopsies taken from



Fig. 3.—Patient G. T., 22 days after start of experiment. Patient's left side treated with nickel pectinate jelly and now nearly healed. His right side dressed with cod liver oil ointment still shows hypertrophic granulations. Unfortunately, no initial photograph was taken. However, at the beginning, 6 days after pinch grafting, the two sides, with the exception of the infraclavicular regions, were nearly identical.

the contrasting areas of these wounds (Fig. 7) showed young, edematous, vascular granulation tissue on the cod liver oil side and condensed, older looking granulation tissue on the pectinate side. Final healing was recorded in only 2 wounds. In one (Fig. 4) both the nipectin and the cod liver oil-dressed halves were healed on the thirty-first day. In the other (Fig. 5) healing occurred on the pectin side in 71 days, on the cod liver oil side in 63 days. It is not surprising that healing in these excavated wounds was, if anything, slightly delayed by nickel pectinate therapy, since as already demonstrated, pectin retards granuloplasia.

*The Use of Nickel Pectinate on "Dermatome" Splint-Thickness Donor Sites.*—It appeared logical that if nickel pectinate dressings achieved their remarkable epithelizing effect chiefly by "holding back" granulation tissue overgrowth so antagonistic to skin healing, one portion of a split-thickness donor site, taken by a Pagett dermatome and dressed with nickel pectinate, should heal no more rapidly than another area of identical depth dressed with some control agent, since the base in both areas is made up of a residuum of corium that restrains granulation tissue overgrowth.

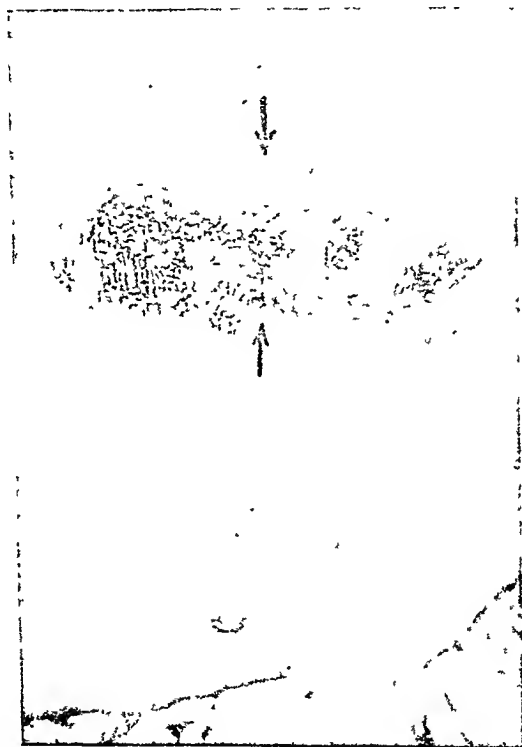


Fig. 4.—Patient W. B., Lesion, an infected, partly eviscerated, upper abdominal transverse incision, 18 days after start of bilateral dressings. Adherent anterior stomach wall formed one-half of the wound floor on the right, about one-quarter of the floor on the left. Nickel pectinate dressings on the right, cod liver oil on the left. Note that already granulations are luxuriant on the cod liver oil side and barely beginning on the pectinate side.

This experiment was carried out six times in 4 patients. Nickel pectinate dressings and cod liver oil or sulfonamide ointment dressings being applied side by side on the same area denuded about three-quarter thickness by the dermatome. As had been expected, healing was no faster on the experimental than on the control areas. In fact, the average healing time for the pectin areas was 18 days and for the control areas only 16.2 days. There was a striking difference in appearance between the two areas. The healed surface on the nickel pectinate treated



side was pale and absolutely smooth. The control-dressed surface was of a ruddy appearance and finely pebbled by virtue of tiny little granulations starting to push up through the corium but epithelized before they attained any size.



Fig. 5—A, Patient O A, lesion, infected appendectomy wound at the start Nickel pectinate dressings applied to medial half of wound, cod liver oil dressings to the right B, Same lesion 14 days later. Note the flattened white granulations on the pectinate side, the exuberant granulations on the control side.

Cannun and Cope<sup>8</sup> compared the rate of healing of different areas of dermatome donor sites when dressed with different agents. However, the residuum of corium at the base of all such denudations restrains granulation tissue overgrowth and furnishes a myriad of foci for epithelial cell regeneration. A true test of epithelization can only be made on granulating surfaces devoid of any dermal remnants (see Discussion).

*Bacteriology.*—Nearly all of the wounds in this investigation were cultured one or more times. Since all had reached the granulating “surgically clean” phase before the start of the present study, little attention was paid to their flora, since experience has shown that by the time a wound enters the granulating stage it is usually adapted to its

A.



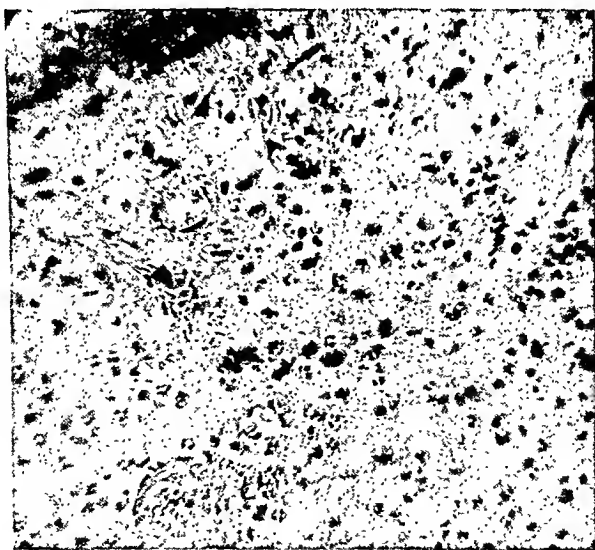
B.

Fig 6—A, Patient G. M., lesion, infected bilateral inguinal dissection wound for carcinoma of penis, at start of experiment. To patient's left, nickel pectinate jelly dressings, on the right side cod liver oil ointment. B, Same patient 14 days later. On the pectin side the granulations are flat and whitened, on the cod liver oil side, they are high, turgid and rosy



A.

Fig. 7.—Photomicrographs of granulating base of wound (Patient G. M., see Fig. 6).  
A.—From nickel pectinate-dressed side.



B.

Fig. 7.—B.—From cod liver oil-dressed side. The cod liver oil side (B) shows very young fibroblasts, widely separated by marked intercellular edema. There are numerous blood vessels and rather dense infiltration of polymorphonuclear and plasma cells. On the pectinate side (A) the fibroblasts are more closely placed, their nuclei smaller and in places pyknotic. There is less vascularity and less leucocytic infiltration.

own organisms and that its rate of healing is not necessarily increased by reducing its bacterial count, unless virulent organisms are present. By far the commonest organism found was the *Staph. aureus*. The *Strep. hemolyticus* was fairly frequent while *B. pyocyaneus* and *B. proteus* were occasionally present. The average healing time for wounds culturing *Staph. aureus* alone (with or without lesser organisms such as *B. pyocyaneus* and *B. proteus*) was almost exactly that for wounds culturing both *Staph. aureus* and *Strep. hemolyticus*—37.2 days for the former and 37.1 days for the latter. On two occasions, however (patients D. B. and W. D., Table I), wounds that were practically healed went into a retrogression, their new epithelium melted away, and they became shaggy and purulent. Their culture, previously *Staph. aureus*, now also revealed *Strep. hemolyticus*. In these two cases the intercurrent hemolytic streptococcus was doubtless virulent and responsible for the retrogression.

The nickel pectinate was definitely more bacteriostatic than its control, cod liver oil ointment. Exudate was usually less. On five occasions, after a wound had been dressed for from 7 to 9 days on one half with nickel pectinate and on the other with cod liver oil, colony counts were taken from both areas. Without exception the count on the control side was from two to ten times that of the experimental side.

#### RABBIT EXPERIMENTS

Nearly identical wounds were produced in 6 rabbits, one on either side of the spine, extending down to the paraspinal fascia and in one case through the fascia into the muscle. The skin borders (except in one case where circular incisions were made) were tacked to the underlying fascia. In each rabbit the wound on the right was dressed with cod liver oil ointment, that on the left with nickel pectinate jelly. The wounds were treated at least once daily, sometimes oftener. The gauze outer dressings were held in place fairly well by means of threads passed back and forth through skin clips that had been applied around the wounds in the normal skin.

Cultures taken after the sixth day showed a pure culture of *Staph. aureus* in all wounds. Four of the 6 cod liver oil-dressed wounds showed well-developed granulation tissue formation beginning about the seventh or eighth day. However, this never became an overgrowth such as frequently retards epithelization in human wounds. In the pectinate-dressed wounds there was never more than slight evidence of granulation tissue activity. Owing, doubtless, to the extreme looseness of the rabbit's hide, healing in all cases was chiefly due to contraction or cicatrization of the wound borders and involved only a slight amount of new epithelization. It is interesting that without exception healing came first on the cod liver oil side, occurring 15, 14, 13, 5, and 3 days

sooner, their average healing time being 32 days. A possible explanation for this relatively rapid healing of the control wounds is that since contraction of granulation tissue is one of the chief mechanisms of wound cicatrization, and since cod liver oil stimulates granulation tissue formation, cicatrization should therefore be accelerated in wounds dressed with this vitamin ointment. Nor is there in rabbits the tendency to granulation tissue overgrowth, the control of which in human beings gives pectin-dressed wounds the advantage during the stage of epithelization.

#### DISCUSSION

Wound healing, as pointed out by Alexis Carrel,<sup>9</sup> is not a simple and uniform closure of a defect by cell multiplication; it is a balanced co-operation between repair by granulation tissue and epithelization, each process governed by its distinct stimuli. Where the area of the wound is large in relation to its depth, the balance in healing is apt to be tipped in favor of granuloplasia, with the resulting familiar picture of "proud flesh" mushrooming out over the skin borders or burying in its depths pin-point grafts. From the foregoing, then it appears that nickel pectinate, by inhibiting granulation tissue overgrowth, restores a normal balance and allows epithelization to proceed at approximately its normal rate. Conversely, nickel pectinate will exert little if any effect upon the healing of a wound in which there is no exuberance of granulations.

The findings in this study are diametrically opposed to those of Tompkins,<sup>11</sup> Norton,<sup>12</sup> and their co-workers. These authors, the former on a basis of clinical experimentation, the latter from experiments on wounds in rats, both conclude that pectin and nickel pectinate promote wound healing up to the stage of epithelization, but actually retard the final proliferation and closing over of the skin. Possibly the pectin, the percentage of nickel, or the strength of merthiolate we have used may explain the difference in our results. Tompkins and associates used plain pectin 2 per cent, with merthiolate 1:200,000. Norton and co-workers used pectin 5 per cent, nickel 0.032 per cent, no mention of merthiolate. Our preparation contains pectin 3 per cent, nickel 0.045 per cent, merthiolate 1:5,000, and in most cases tragacanth 10 per cent. It is significant that Thomson's<sup>5</sup> first clinical trial of pectin revealed remarkable epithelization of an extensive granulating burn which other agents and several skin grafts had failed to heal.

Violle and Saint-Rat<sup>13</sup> and others have claimed that pectin is a hemostatic and hastens the clotting of blood. This is denied by Norton and colleagues<sup>12</sup> on a basis of *in vitro* experiments. I have observed that pectin does have an indirect hemostatic action in that it renders granulation tissue more dense, compact, and less vascular. Granulations dressed with other bland agents are turgid, rosy, and bleed easily, in contrast to the pale, flat, nonbleeding pectin granulations.

## SUMMARY

1. The present study covers a period of four years during which time 65 wounds in 61 patients were dressed with nickel pectinate and as controls, 34 comparable wounds in 31 patients were treated with various bland agents, chiefly cod liver oil or ointment. In addition, controlled wound healing experiments were carried out in 6 rabbits.

2. An apparently satisfactory control method was employed in 22 cases, in which larger wounds, nearly uniform throughout, were divided into two comparable areas, the one dressed with the experimental agent, the other with the control.

3. Contrary to prevailing opinion, we have found that nickel pectinate does not promote wound healing, but instead depresses granulation tissue proliferation.

4. By virtue of its property of keeping down "proud flesh," nickel pectinate indirectly exerts a definite acceleration of epithelization (22 per cent reduction in healing time over such control agents as cod liver oil or foille). Hence, it is contraindicated in the early stages of wound healing, but is an ideal dressing where epithelization is sought.

5. Nickel pectinate is mildly antiseptic. Compared to cod liver oil ointment, it causes greater reduction in wound exudation and a marked reduction of the colony count.

6. Nickel pectinate is hemostatic to a certain point in that it condenses and renders less vascular granulation tissue with which it comes in contact.

## REFERENCES

1. Block, L. H., Tornowski, A., and Green, B. H.: Pectin and Nickel Pectinate in Acute and Chronic Bacillary Dysentery, *Am. J. Digest. Dis.* 6: 96, 1939.
2. Haynes, E., Tompkins, C. A., Crook, G. W., and Winters, M.: Bactericidal Action of Pectin Containing Compounds, *Proc. Soc. Exper. Biol. & Med.* 39: 478, 1938.
3. Arnold, L.: The Bactericidal Action of Pectin and Metal Pectinates, *Am. J. Digest. Dis.* 6: 104, 1939.
4. Myers, P. B., and Rouse, A. H.: Pectinates, With Special Reference to Nickel Pectinate and Their Therapeutic Value, *Am. J. Digest. Dis.* 7: 89, 1940.
5. Thomson, E. M.: Pectin in the Treatment of Infected Wounds, *Indust. Med.* 7: 441, 1938.
6. Manville, I. A., Bradway, E. M., and McMinis, A. S.: The Use of Apple Powder in the Treatment of Diarrheal Conditions and Its Rationale, *Canad. M. A. J.* 36: 252, 1937.
7. Smith, E. D.: Glycerin Osmotic Drainage, *Am. J. Surg.* 50: 55, 1940.
8. Cannon, B., and Cope, O.: Rate of Epithelial Regeneration, *Ann. Surg.* 117: 85, 1943.
9. Carrel, A.: The Treatment of Wounds, *J. A. M. A.* 55: 2148, 1910.
10. Anderson, D. P., Jr.: The Problem of Wound Healing, *Ann. Surg.* 108: 918, 1938.
11. Tompkins, C. A., Crook, G. W., Haynes, E., and Winters, M.: Pectin in the Treatment of Various Types of Wounds, *Surg., Gynec. & Obst.* 72: 222, 1941.
12. Norton, P. L., Wilson, L. P., Johnston, R., and Rosa, D. G.: The Effect of Pectin and Nickel Pectinate on the Healing of Granulating Wounds in Albino Rats, *Am. J. Surg.* 56: 573, 1942.
13. Violle, H., and Saint-Rat, L.: Hemostatic Properties of Pectin, *Compt. rend. Soc. de Biol.* 180: 603, 1925.

## PLASMA CLOT SUTURE OF NERVES—ILLUSTRATED TECHNIQUE

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THE conventional method for uniting severed nerves has been by the use of thread stitches, preferably silk. Although an attempt is made to confine the stitches to the epineurium, nerve fibers are at times included with resultant strangulation of tissue and subsequent fibrosis. Further interference with successful regeneration may result from the knuckling of the nerve fibers when the threads are tied. The need for an improved technique is particularly apparent when dealing with small nerves where the silk sutures may strangulate a considerable proportion of the nerve fibers with great likelihood of unfavorable functional results. Young and Medawar<sup>1</sup> have attempted to avoid these difficulties by the use of cockerel plasma clot with chick embryo extract. The inconveniences involved in the preparation of these materials and, more particularly, the inflammatory and fibrotic reactions resulting in animals of other species led to the introduction of the technique of autologous plasma clot suture of nerves.<sup>2</sup> Less obstruction to regenerating nerve fibers occurs with autologous than with heterologous plasma clot. The development of a suitable mold<sup>3</sup> in which nerves can be sutured with plasma clot has made possible accurate alignment and stronger union of the nerve ends. The technique of suturing peripheral nerves and nerve grafts by means of plasma clot has been described in previous publications.<sup>3, 4</sup> It was pointed out that when nerve ends cannot be united without tension, then plasma clot suture alone is undesirable since the junction may subsequently separate. Following a suggestion by Lt. Col. R. Glen Spurling, tantalum wire\* (0.0025 or 0.003 inch in diameter) has been employed as tension sutures to approximate the nerve ends while accurate apposition is achieved by means of the plasma clot. The tension sutures are placed well back from the primary suture line and serve to protect it from strain. Single strands of untwisted 00 Corticelli black silk (or white silk) may be used as tension sutures. Although the silk is easier to tie than is the tantalum, it is not as strong and there is more risk of the silk breaking when the strain at the suture site is great. Moreover, the tissue reaction is greater with silk than

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\*The tantalum wire was kindly supplied by the Fansteel Metallurgical Corporation.

Fig. 3.—The two tantalum wire tension sutures have been introduced at a distance of approximately 1 cm. from the cut ends of the nerve. The insert shows the manner in which the wires are applied. For the sake of convenience one end of the wire, threaded on a small curved ophthalmic needle, is bent sharply before it is introduced and it is then pulled through the nerve to the point of its angulation. (*A*). The tension sutures are carried somewhat deeper than the epineurium since in vitro tests of the tensile strength of nerves joined with tension sutures (tantalum wire or silk) have shown that the values obtained are almost twice as great when the stitches include a small amount of nerve substance rather than when they penetrate only as deep as the epineurium. The wire is then twisted so that one obtains a fairly straight pair (*B*) rather than two wires which tend to separate and assume a curved form due to the springiness of the metal. The length of the twisted pair of wires is made somewhat greater than the distance between the points of insertion of the tension sutures through the nerve when their ends are approximated. The wires are grasped by fine forceps and pulled backward; the length of the twisted pair of wires is thus shortened until the nerve ends may be approximated without strain. When this point has been reached, the long end of the wire is bent with a forceps as shown in *D*. The sharp bend prevents sliding of the nerve on the wire with ensuing separation of the nerve ends along their longitudinal axis. The very short twists which have been formed by pulling the wires backward (shown in *C*) act as a block to prevent excessive tightening of the wire when the ends are tied. The wires are tied in the form of a square knot (*D*) which is preferable to twisting the wires since the resulting sutures are thus rendered stronger. Both slipping of the wires and excessive tightening of them must be avoided since, should this occur, either a gap between the nerve ends would result or the stumps would be pressed against each other with knuckling of nerve fibers. Unless close apposition of the nerve ends is obtained, organization of the plasma clot insinuated between them would lead to the formation of connective tissue which interferes with the proper downgrowth of nerve fibers. On the other hand, if the nerve stumps are compressed as a result of excessive shortening of the wires, there results disruption of the proper longitudinal organization of the nerve fibers at the suture site. The manner of introducing and tying the tantalum wire tension sutures is given in detail since their correct adjustment is a most important step in the technique of tantalum wire-plasma clot suture of peripheral nerves.





Fig. 3. (For legend see opposite page)



Fig. 4—The nerve ends are adjusted on the wire rails so that accurate coaptation is obtained. The tension wires are shown. The clips have been applied to the fins of the mold as close as possible to the air foam collar to prevent leakage of plasma from around the nerve. The insert shows the clip as it appears at the end of the clip holder. The mold is then filled with plasma, approximately 20 drops from a Wintrobe pipette. Originally a period of approximately twenty five minutes was allowed before removal of the mold since this is the time required for the clot to achieve its maximum stability. However the clot becomes quite firm in about ten minutes and it is quite safe to remove the mold at the end of this period of time. The unmodified plasma (plasma to which no anticoagulant is added) is allowed to clot spontaneously since it has been found that the addition of most anticoagulants and coagulants to the plasma weakens the clots prepared from it. Recently, however, we have found that heparinized plasma coagulated by means of protamine sulphate yields clots which are as strong as those prepared from unmodified plasma. Heparinized plasma is prepared by adding 0.05 c.c. of liquaemin to 10 c.c. of blood and then 0.9 c.c. of the heparinized plasma is clotted by the



Fig. 5.—The handle of the wire rail is grasped by a forceps and is being withdrawn preparatory to removal of the mold. One clip has been removed. The upper insert shows the sutured nerve after both of the wire rails and clips have been removed and the mold carefully peeled away from the clot.

addition of 0.1 c.c. of a solution containing 0.125 mg. of protamine sulfate per 100 c.c. of distilled water. The heparinized plasma and the protamine are premixed immediately before being introduced into the latex mold for nerve suture. The use of heparin-protamine plasma offers a practical advantage in that the inconveniences involved in the preparation of unmodified plasma (collecting the blood in paraffin-lined test tubes packed in ice and centrifuging it in 250 c.c. metal cups filled with ice in order to prevent clotting) may be obviated. (Liquaemin by Hoffmann-La Roche, Inc.)



Fig. 6.—The mold is grasped by forceps and removed while the sutured nerve is protected by a spoon. The inserts show the nerve sutured by the combined tantalum wire plasma clot technique. The tantalum wire is shown through the clot (left insert). Usually the opacity of the clot obscures the tension wires which are incorporated in it (right insert).

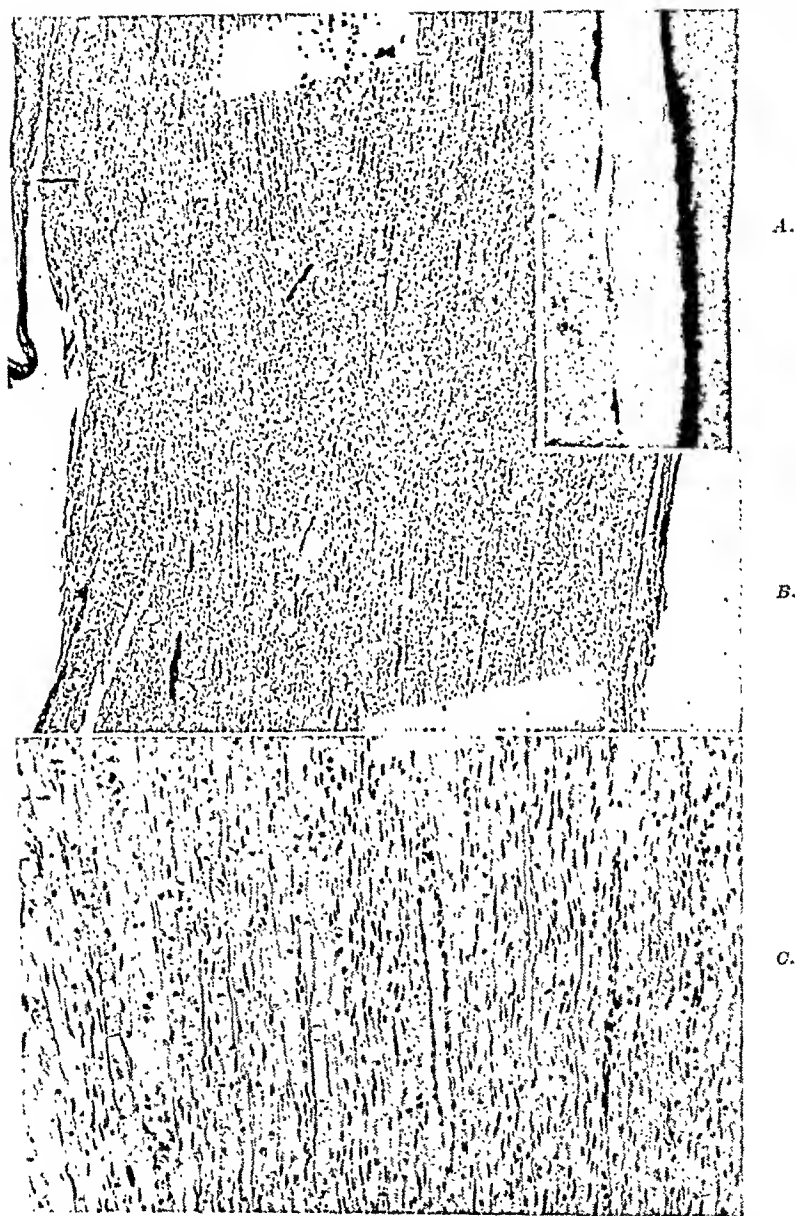


Fig. 7.—Photographs showing *A*, gross, and *B* and *C*, microscopic appearance of the sciatic nerve of a dog sutured by the tantalum wire-plasma clot technique. Note the tantalum wire tension sutures in the nerve (*A*) removed fifty-four days after suture. Photomicrographs show practically no inflammatory or fibrotic reaction at the junction thirteen days after suture. Sections stained with hematoxylin and eosin (*B*  $\times 30$ ; *C*  $\times 140$ ).

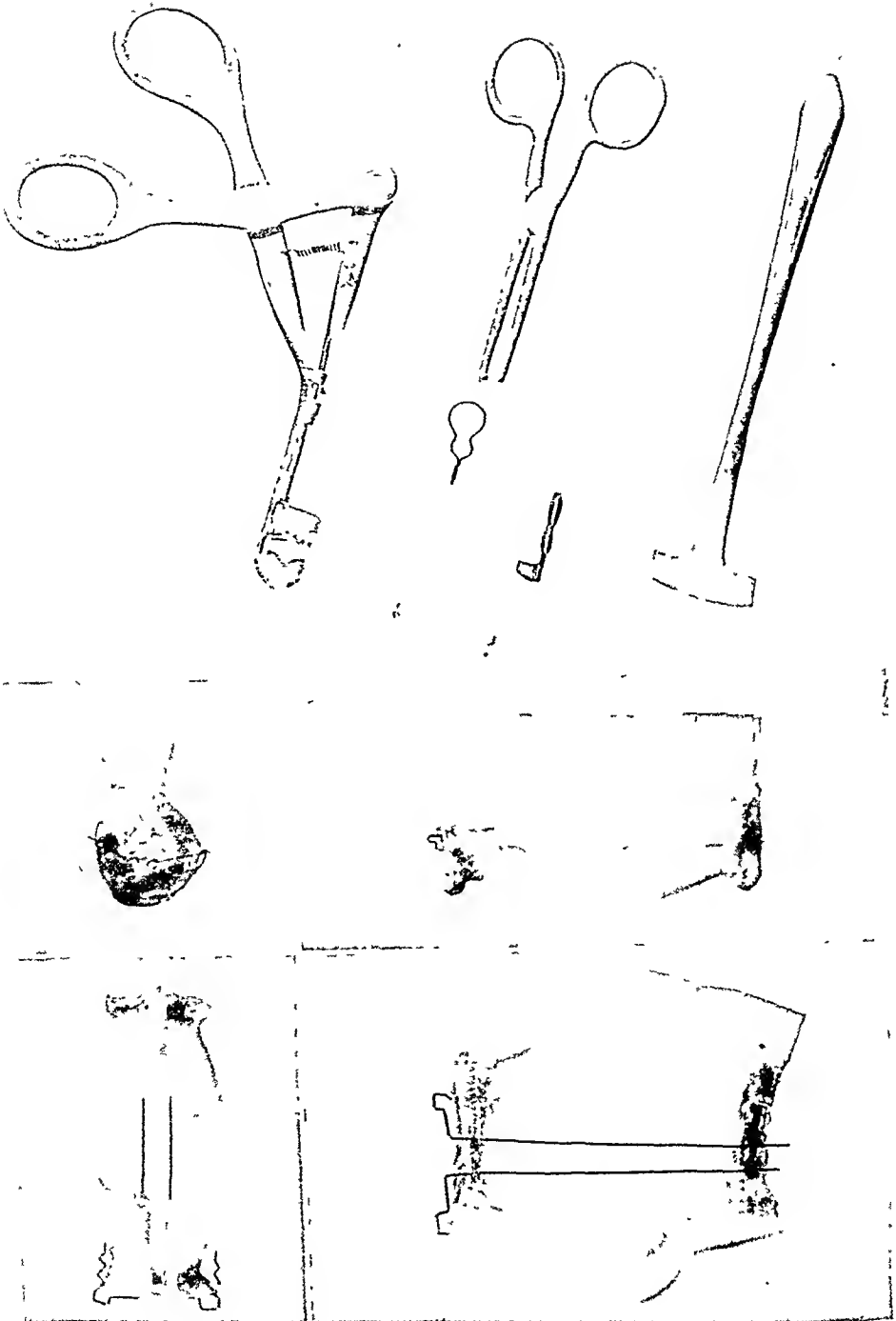


Fig. 8. (For legend see opposite page.)

with tantalum. It is the purpose of this communication to illustrate, mainly by means of photographs which have not been retouched, the technique of tantalum wire-plasma clot suture of peripheral nerves. The use of this combined technique eliminates the likelihood of separation of the sutured nerve ends. The photographs were taken at an operation upon the sciatic nerve of a dog.

Autologous plasma clot suture of peripheral nerves was done in five human patients.<sup>2</sup> In two of these cases sufficient time has elapsed for some evaluation of the results. In one case, functional recovery of the sternocleidomastoid muscle began two months after the spinal accessory nerve was sutured at a point approximately 4 cm. before its entrance into the muscle; complete recovery of muscle function occurred five and one-half months after the operation. The nerve had been sutured by depressing the nerve ends into the neighboring tissues to form a trough in which the plasma could collect. The nerve ends were held together with jeweler's forceps until clotting occurred. A suitable mold was not available at the time when this operation was done, so that this cruder technique had to be employed. The nerve was sutured one hour after it had been severed at operation. In another patient the ulnar nerve at the level of the wrist was sutured by the combined tantalum wire-plasma clot technique. The nerve, which had been severed fifteen months previously, was freed for a considerable distance proximal and distal to the stumps and the combined technique had to be used since the nerve ends to be united were under considerable tension. When last examined, eighteen week after operation, the patient had shown considerable return of sensation for pinprick, cotton-wool, and hot and cold objects over the hand and fingers down to and including the proximal half of the distal phalanx of the fifth finger. Before operation the area of sensory loss involved the fifth finger, the ulnar half of the fourth finger, and the inner part of the palmar and dorsal aspects of the hand as far as the wrist. Also during the interval between the tenth and eighteenth weeks postoperatively, there occurred improvement in the power of flexion of the fourth and fifth fingers and it has become possible to abduct and adduct the fingers to a slight extent.

\*The author is indebted to Dr. Leo M. Davidoff and Dr. Thomas Hoen for referring these patients to him.

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Fig. 8.—Photographs showing molds and instruments devised for plasma clot suture of nerves: nerveholder with grooved air-foam cushions, clips and clip holder, latex mold, and the spoon which is used for protection of sutured nerve during removal of mold. Below are shown end, side, top, and interior views of latex mold. The use of the wire supporting rails shown in the mold make it possible to obtain accurate apposition of the cut ends of the nerve and also to surround uniformly the suture site with plasma clot.

The molds are designed for nerves the size of the dog's sciatic nerve, and have a capacity of approximately 20 drops of plasma. For larger or smaller nerves, molds of appropriate sizes are kept on hand. The openings in the air-foam collars of the molds are made round and oval to accommodate variations in shape of nerves.

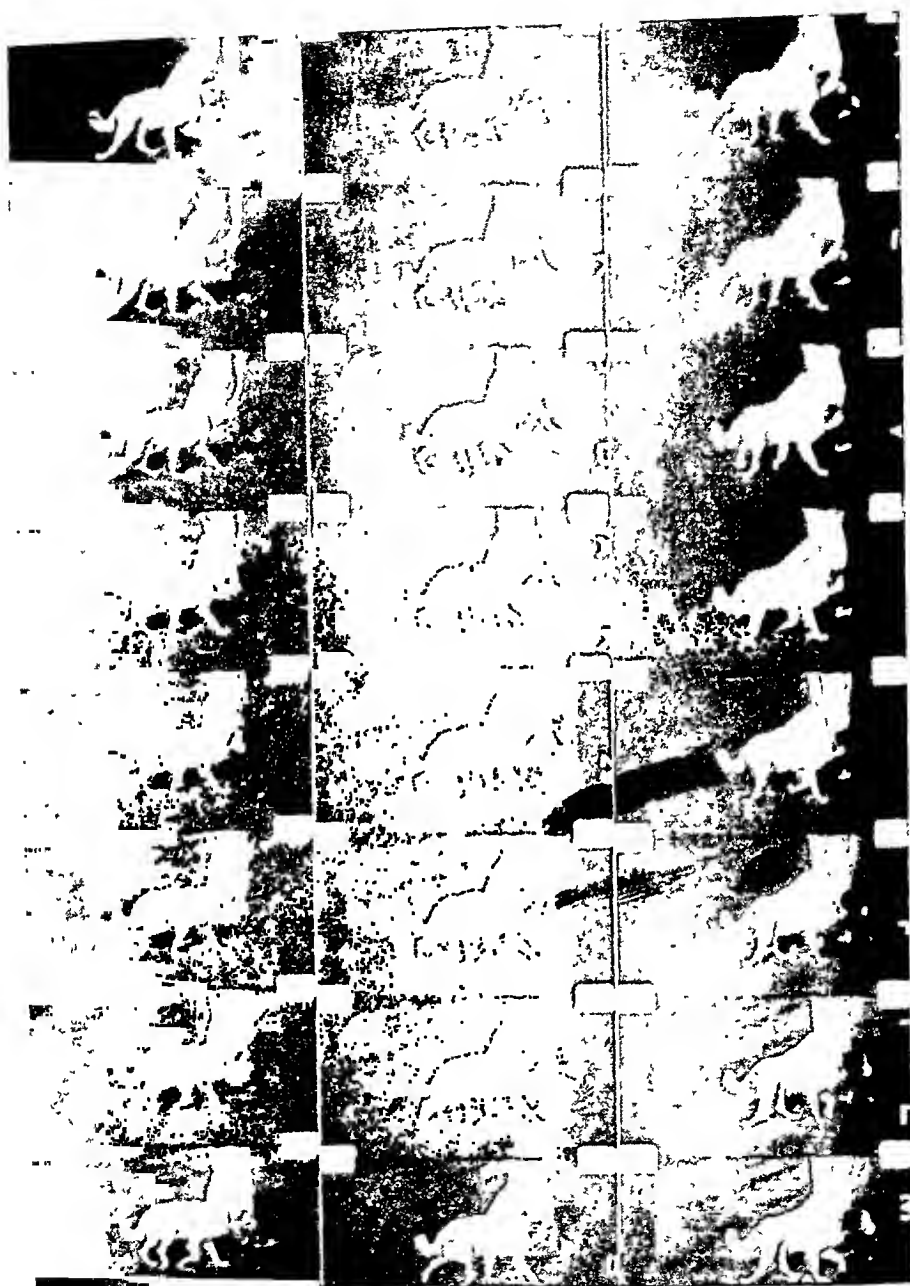


Fig. 9.—Series of photographs from a motion picture film showing complete cycle of movements of hind limbs of a dog in which the left sciatic nerve was sutured with autologous unmodified plasma and the right with silk (single strands of untwisted 00 Corticelli silk). Photographs were taken eighty-four days after operation, since which time complete recovery of motor power on the right as well as the left side occurred. Such a difference in the rate or degree of recovery of function which could be attributed to the different methods of suture has not been consistent in our animals, although the results tend to be better with autologous plasma clot suture. The superior gross and histologic results associated with plasma clot would lead one to anticipate correspondingly better functional return to the innervated part than with silk suture. Further correlative studies will be necessary to test this point.



The results of plasma clot suture of nerves are encouraging and justify further use of the method in cases involving human beings.

The molds and instruments used for the suture of nerves with plasma clot were made by Mr. Cornelius Denslow and Mr. Saul Swarz. The sketch which illustrates the technique of applying the tantalum wire tension sutures was made by Dr. Joseph A. Epstein to whom the author is also indebted for operative assistance. The photograph shown in Fig. 1 was taken by Mr. W. Abbey and those shown in Fig. 2 are from a motion picture film taken by Mr. Lester Bergman. Other photographs are by Louis Armonath.

#### REFERENCES

1. Young, J. Z., and Medawar, P. B.: Fibrin Suture of Peripheral Nerves, *Lancet* 2: 126, 1940.
2. Tarlov, I. M., and Benjamin, B.: Autologous Plasma Clot Suture of Nerves, *Science* 95: 1258, 1942.
3. Tarlov, I. M., and Benjamin, B.: Plasma Clot and Silk Suture of Nerves, *Surg., Gynec. & Obst.* 75: 366, 1943.
4. Tarlov, I. M., Denslow, C., Swarz, S., and Pineles, D.: Plasma Clot Suture of Nerves: Experimental Technique, *Arch. Surg.* 47: 44, 1943.

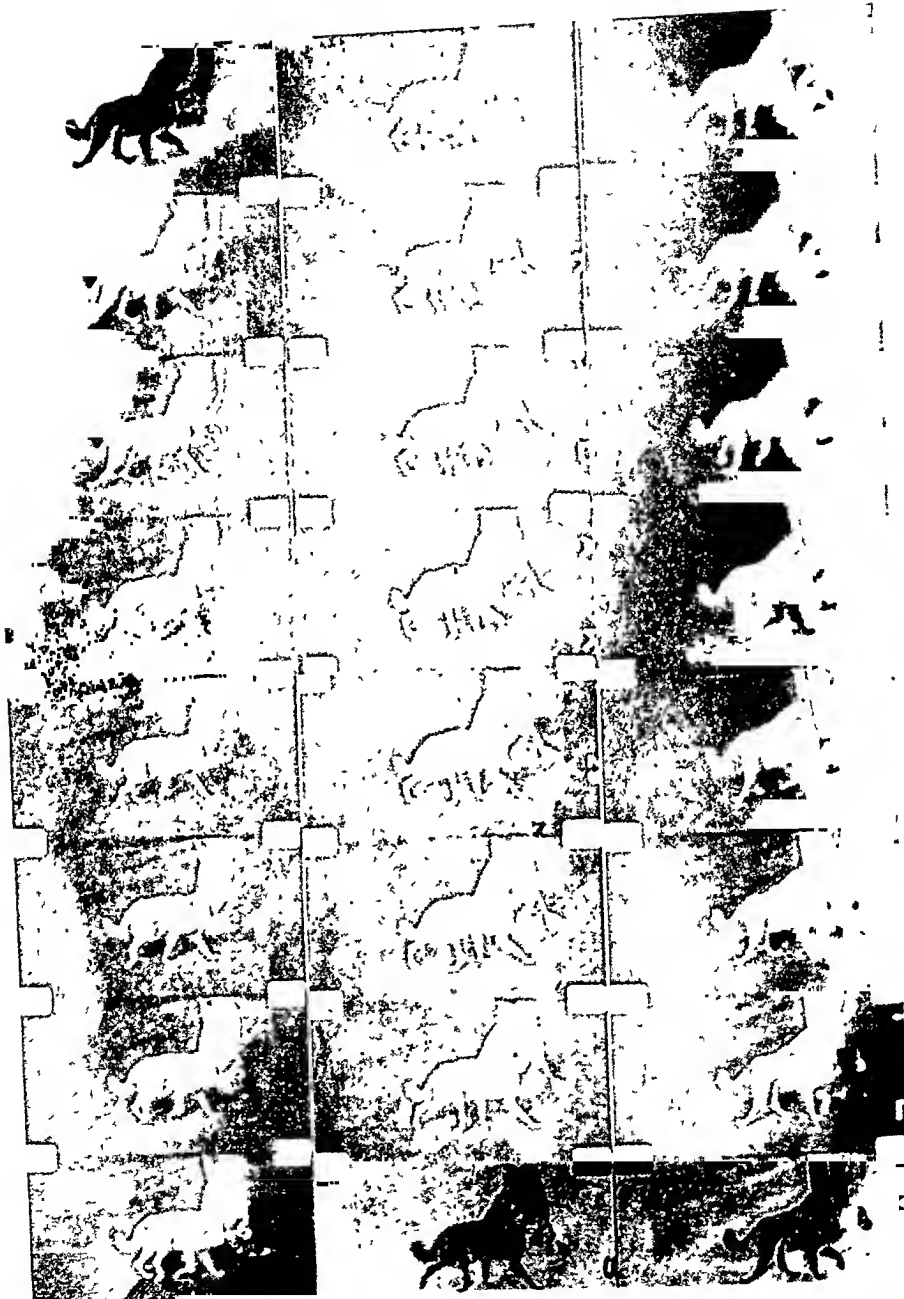


Fig. 9.—Series of photographs from a motion picture film showing complete cycle of movements of hind limbs of a dog in which the left sciatic nerve was sutured with autologous unmodified plasma and the right with silk (single strands of untwisted 00 Corticelli silk). Photographs were taken eighty-four days after operation, since which time complete recovery of motor power on the right as well as the left side occurred. Such a difference in the rate or degree of recovery of function which could be attributed to the different methods of suture has not been consistent in our animals, although the results tend to be better with autologous plasma clot suture. The superior gross and histologic results associated with plasma clot would lead one to anticipate correspondingly better functional return to the innervated part than with silk suture. Further correlative studies will be necessary to test this point.

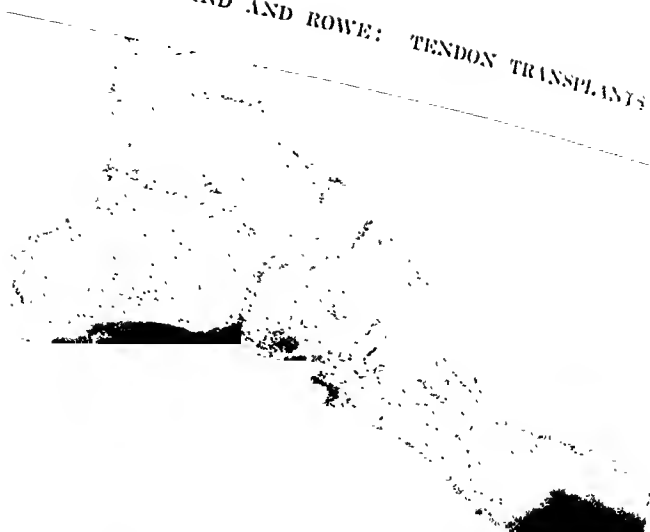


Fig. 14.

Fig. 1.—Lateral transportation of anterior tibial tendon with nail fixation; equinovarus, no cast.



Fig. 1.

B.  
tion of medial malleolus after fracture



Fig. 3.

Fig. 3.—Reattachment of tibial tubercle with attached patellar tendon after synovectomy; no cast, early function.



Fig. 4.

Fig. 4.—Reattachment of greater trochanter after arthroplasty; no cast, early function.



Fig. 5—Reduction of medial epicondyle after fracture, no cast, early function



Fig. 6.—Attachment of avulsed long biceps tendon origin to bicipital groove, no external immobilization, early function.

As is well known, there is considerable difference between the sexes in the occurrence of these fractures. In 136 cases of all types of hip fractures which I have seen, occurrence was found, as shown in Table II.

TABLE II

FRACTURES OF THE FEMUR	MALES (PER CENT)	FEMALES (PER CENT)
Of the neck	25.3	74.7
Trochanteric	54	46

In general, therefore, it can be said that more than half the cases of trochanteric fractures occur in men and nearly two-thirds of the cases of neck fractures occur in women.

A similar characteristic variation is found in the hips involved, as shown in Table III.

TABLE III

FRACTURES OF THE FEMUR	LEFT HIP (PER CENT)	RIGHT HIP (PER CENT)
Of the neck	62	38
Trochanteric	47.8	52.2

## MORTALITY

That intertrochanteric fractures result in high death rates has been commonly noted. Wilson, at the Massachusetts General Hospital, reported 24 per cent mortality in a group of 62 cases; Leyding, at the St. Louis City Hospital, found 39 per cent mortality; and Taylor, in Los Angeles General Hospital, found 30 per cent mortality. Of 65 intertrochanteric fractures which I have followed, 15 patients died within two months of the accident (22.2 per cent mortality). These observations lead to the obvious conclusion that intertrochanteric fractures are a most potent cause of death in the aged.

## CLASSIFICATION OF TROCHANTERIC FRACTURES

Many years ago, Percivall Pott stressed the importance of determining the type of hip fracture before instituting treatment because "they so often lame the patient and disgrace the surgeon." Sir Astley Cooper was the first to emphasize the difference between the intracapsular (neck) fractures and the extracapsular (trochanteric) fractures in relation to their probability of union.

The older writers divided trochanteric fractures into (1) comminuted fractures at the base of the neck and (2) "mixed" fractures at the base of the neck. The "mixed" fractures were partly intracapsular (on the front surface of the neck) and extracapsular (on the posterior surface of the neck) because of the uneven attachment of the capsule. Petro-

chanteric fractures were identified as those which passed through the base of the neck and shaft distal to the greater trochanter and proximal to the lesser trochanter. Subtrochanteric fractures were those which occurred in the shaft just distal to the lesser trochanter.

Böhler's description of the principal types of trochanteric fractures of the femur seems as nearly adequate as any:

1. Fracture through the base of the neck outside the capsule with slight displacement.
2. Fracture through the trochanters with outward rotation of the leg and wide separation of the fragments.
3. Fracture with the base of the neck driven deeply into the spongy mass of the trochanters.
4. Fracture line in the region of the trochanters, often with comminution.



Fig. 1.—Simple type of fracture through the base of the neck of the femur with no displacement

Of course as in all fractures, there are many diverse types of trochanteric fractures which may or may not conform to this broad classification. Moreover, there are wide differences in the degree of comminution or displacement of fragments which may have much to do with the choice of proper treatment (Figs. 1 to 5).



Fig. 2.—Comminuted fracture through the intertrochanteric region with rotation deformity of the leg and impaction of the base of the neck into the shaft of the femur.



Fig. 3.—Comminuted fracture through the intertrochanteric region with marked upward displacement of the shaft of the femur.



## TREATMENT OF TROCHANTERIC FRACTURES

Unlike fractures of the neck, the treatment of trochanteric fractures is not complicated by the prospect of nonunion. There is a very liberal blood supply to the trochanteric region even in aged adults and each fragment is adequately supplied despite the presence of the fracture. I have never seen a nonunion of a trochanteric fracture and none has been described in case reports as far as I know. The main problem, therefore, is to secure union in normal position without coxa vara deformity, shortening, or external rotation rather than concern about nonunion.



Fig. 4.—Comminuted fracture distal to the greater trochanter with angulation of the fragments.

The following types of treatment have been used with varying degrees of success:

1. External splints
2. Traction devices

3. Internal fixation with nails, screws, bolts, etc. It is worth while to consider each plan of treatment with the advantages and disadvantages in order to decide the best type of care for these cases.

1. *External Splints.*—The first splint for fracture of the hip was described by Ambroise Paré, who treated “an honest matron” by placing wooden strips about her thigh and supporting them with a figure-of-eight bandage about the thigh and waist.

In 1871, Hodgen of St. Louis described his wire suspension splint which supported the extremity in a long sling, although it provided no immobilization of the body. This splint has been popular for many years and is still widely used.

An oft-described, but apparently seldom used, hip splint was the Thomas-Ridlon splint (1880). This cumbersome device consisted of a long broad strip of soft iron which passed up the back of the leg and thigh across the buttocks and up to the shoulders. It was bent to conform to the body and was fastened to the patient with straps.



Fig. 5.—Long spiral fracture in the intertrochanteric region with moderate displacement.

Although Senn illustrated a plaster of Paris spica bandage, in 1889, with a lateral pressure screw over the trochanter, the greatest credit is due Royal Whitman who, in 1904, described the abduction spica cast. But Whitman's more significant contribution was the accompanying description of the maneuvers for reducing hip fractures and the recognition of the importance of abduction and internal rotation for locking them after reduction (Fig. 6).

Wilkie attempted to achieve the same position by using casts on each leg which were joined by metal rods to maintain abduction and internal rotation.

External splinting alone, of course, facilitates the healing of trochanteric fractures, but it is not adequate treatment for comminuted

fractures or those with great displacement. The Whitman cast is the only splint which attempts to secure the fragments in normal position, although its usefulness is limited to the simple fractures at the base of the neck.

A great criticism of all external splints is that they confine the patients to such a degree that change of position is rendered difficult. This encourages the formation of pressure ulcers, muscular wasting, and residual joint stiffness which may delay general recovery.

It is plain, therefore, that external splints find their principal role in the treatment of those patients who are too frail to permit the use of internal fixation. Yet, strangely enough, this so-called conservative treatment is attended by such a high death rate that it cannot be considered as an ideal emergency treatment.



Fig. 6.—Oblique fracture through the trochanteric region which was reduced by the Whitman method and immobilized by the abduction cast; solid union in normal position.

2. *Traction Devices.*—The first effort to overcome the shortening of trochanteric fractures by the use of traction was made by Hildanus about 1600, when he advocated a strap about the knee which was attached to ropes and pulleys at the foot of the bed.

In 1850, Gibson of Philadelphia devised a traction splint which utilized the principle of countertraction through the sound leg. Traction on the feet was secured by a tight cloth gaiter.

A great advance in the comfort of patients followed Gurdon Buek's introduction, in 1861, of the familiar adhesive skin traction which was attached to cords and weights at the foot of the bed.

Maxwell (1871) and Ruth (1891) combined longitudinal traction with lateral traction to overcome outward rotation of the leg and to produce more accurate reduction of the deformity.

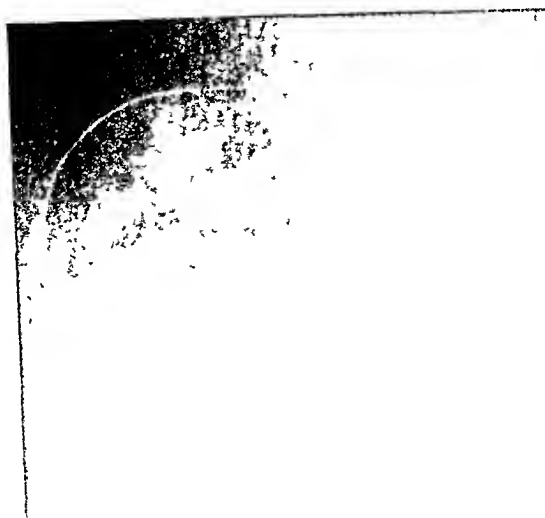


Fig. 7.—Intertrochanteric fracture with no displacement, securely anchored with two long vitallium screws.

In 1921, Russell described his complex "balanced traction" which provided force in two lines so that the knee and thigh each received proper support while longitudinal traction was maintained.

A simpler and better known method of securing traction is the use of adhesive extension while the leg is suspended in a standard Thomas ring splint.

In 1932, Roger Anderson improved the well-leg traction plan by the use of two leg casts fastened to an adjustable apparatus between the legs. Carl Jones utilized the same principle in a device which likewise produced traction on the fractured leg while providing countertraction through the sound leg.

While traction is desirable in most trochanteric fractures to overcome the tendency to shortening and angulation of the neck, it has the disadvantage of holding the patients in the supine position. This in turn increases the likelihood of bed sores and hypostatic pneumonia and, because pain often persists, sedatives are required which in themselves depress the patients.

Well-leg traction in casts permits patients to be turned or to be placed in a wheel chair but, since the knees and ankles are held immobile for many weeks, there is much residual stiffness and weakness after the fracture has healed.



Fig. 8.—Intertrochanteric fracture immobilized in normal position with two vitallium screws.

3. *Internal Fixation.*—The earliest successful internal fixation of intertrochanteric fractures was developed by Denegre Martin of New Orleans, who advocated the use of two long carpenter's screws placed parallel across the fracture line into the neck and head of the femur. Brewster has reported extensive use of the method and has advised long vitallium screws which are less likely to irritate the tissues than the ordinary iron screws (Figs. 7 and 8).

In 1915, Preston described a screw-plate which consisted of a long screw, to penetrate the head and neck, with a plate that was fastened to the shaft of the femur with screws (Fig. 9).

Austin Moore's adjustable pins which were originally devised for fractures of the neck of the femur have been successfully adapted for those trochanteric fractures which are not comminuted.

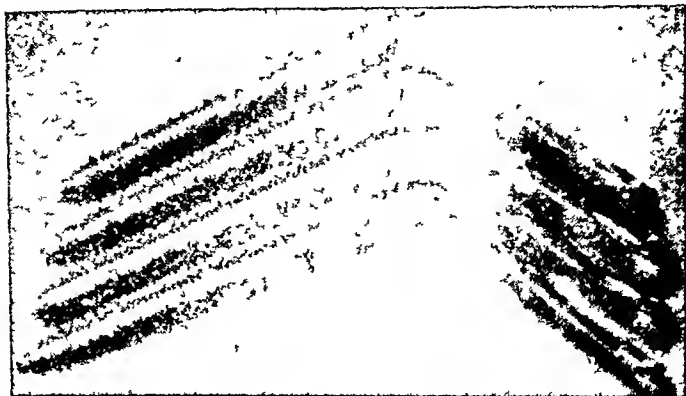


Fig. 9.—Preston's screw-plates for immobilization of intertrochanteric fractures



Fig 10—Fracture through the trochanteric region secured by vitalium Smith-Petersen nail

In the same way, the flanged Smith-Petersen nail has been advocated for intertrochanteric fractures as well as for intracapsular fractures of the neck (Figs. 10 and 11). Thatcher has modified it with a screw which is passed through the head of the nail into the shaft of the femur.

In 1937, Lawson Thornton conceived the idea of screwing an extension plate onto the end of the Smith-Petersen nail in order to provide more

support for fractures in the subtrochanteric region and to prevent the coxa vara angulation which often follows use of the nail alone (Fig. 12).

Overton has suggested the use of a knurled nail head and a knurled intertrochanteric plate to prevent the tendency to loosening which has been reported in cases of plates screwed onto the end of the nails. In Overton's series of 43 cases in which this plate has been used, there has been no case of varus deformity in the late stages of healing.

McKibbin has utilized fixation pins in the upper end of the femur, which were incorporated in a plaster cast about the thigh in order to leave the hip and knee free.



Fig. 11 —Pertrochanteric fracture immobilized by vitallium Smith-Petersen nail.

Roger Anderson recommends fixation pins through the fracture and the shaft of the femur with external bars anchoring all the pins into one unit (Fig. 13). This is a further adaptation of the various Anderson external splints for supporting fixation pins in fractures. In flabby obese patients, however, the soft tissues must be supported by a cast or pads to prevent irritation about the pins and loosening of them.

The numerous appliances which have been developed specifically for fractures of the neck have also been suggested for use in trochanteric fractures. Leydig and Brookes have utilized the Henderson lag screw,

Lippman has adapted his corkscrew bolt, and Morrison has altered his lock bolt by the addition of a plate to anchor the head and neck to the shaft.

Several authors have devised nail-and-plate units suited especially for trochanteric fractures. Neufeld proposed a V-shaped nail in the neck which merged with a flat plate fastened to the side of the shaft with

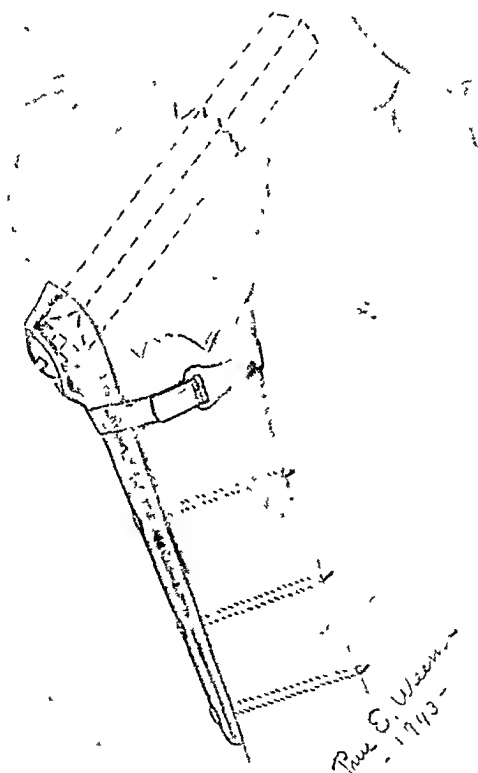


Fig. 12.—Lawson Thornton's plate which is fastened to a Smith-Petersen nail by means of a screw, and to the shaft of the femur with screws or bands. (Courtesy of Lawson Thornton.)

screws. Austin Moore has recently introduced his blade plate which is a simple curved piece which impales the head and neck and conforms to the side of the shaft of the femur. He has used it in 34 cases and has also made the plates in varying lengths to accommodate fractures with much comminution (Fig. 14).

The Jewett nail is a single appliance made of a vitallium Smith-Petersen nail with an attached flat plate to fit the shaft of the femur (Figs. 15 and 16).



Compere has recently recommended the use of a metal plate which is fastened to the shaft of the femur with screws. Threaded pins are then passed through the plate to anchor it to the head and neck of the bone.

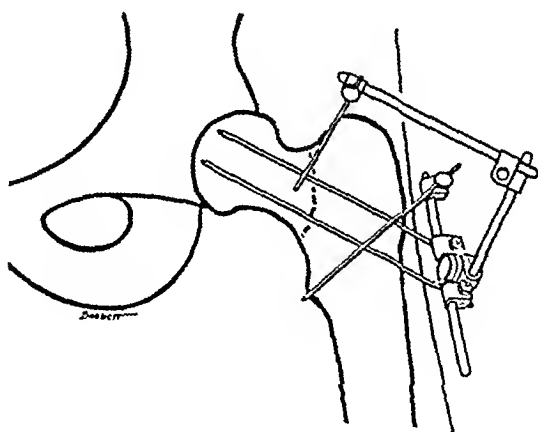


Fig. 13.—Roger Anderson fixation pins and external bars to support fractures in the trochanteric region. (Courtesy of Anderson, McKibbin, and Burgess.<sup>2</sup>)

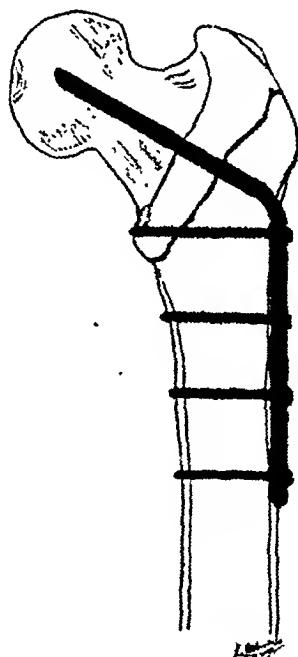


Fig. 14.—Austin Moore's single angle blade plate for intertrochanteric fractures.

Modern anesthetics of much less shocking action and reaction-free intravenous solutions have made surgical operations on elderly patients much less hazardous than in former years. Moreover, since patients with

trochanteric fractures can anticipate poor results with so-called conservative treatment, it is advisable to consider internal fixation of these fractures whenever possible.

A patient with properly applied internal fixation of the fracture experiences little pain and consequently requires few narcotics. The nursing care is simpler, positions can be changed easily and without discomfort, and long hospitalization is unnecessary.



Fig. 15.—Jewett angle nail providing fixation of a displaced fracture in normal position.

Nails, screws, or bolts alone are satisfactory if the fracture is at the base of the neck with little displacement, and if there is an intact lateral cortex. A hazard in the use of such appliances, however, is the frequency of fracture lines into the greater trochanter, which weaken it as a support for the nail. As a consequence, nails may come loose and a coxa vara deformity result. Also, in the operation the lateral cortex sometimes splits and thus provides no adequate support for the nail.

The more recently developed nails (Neufeld's, Moore's, and Jewett's) have many superiorities over the others in that they pass across the fracture line and also are anchored to the shaft of the femur with

screws. Their insertion is more difficult and a longer incision is required, but these disadvantages are outweighed by the nearly perfect fixation which can be secured.

In any method of internal fixation of fractures of the hip, nothing is gained by early ambulation. Frequent change of position in bed and freedom of movement of the legs are sufficient exercise to prevent hypostatic pneumonia or pressure ulcers. The recent work of Urist demonstrates plainly that overstrain of a healing fractured hip may easily damage developing blood vessels and lead to late destructive changes in the femoral head. On the other hand, if a patient is kept in bed for at least eight weeks after the operation, there is far less danger of circulatory injury at the fracture site.



Fig. 16.—Jewett angle nail supporting a comminuted pertrochanteric fracture in normal position.

In the 65 cases of intertrochanteric fractures before mentioned, the treatment methods listed in Table IV were used.

The most satisfactory functional results were obtained in those cases which were treated by internal fixation and the angle nails which were secured to the shaft of the femur were the most successful appliances used. There was very little postoperative pain, the patients moved

TABLE IV

TREATMENT METHODS	NO. OF CASES
Traction in Thomas splint	16
Jewett or Neufeld angle nail	15
Smith-Petersen nail	10
Two vitallium screws	9
Wharton abduction cast	8
Smith-Petersen nail with plate	7
Total	65

freely in bed, and coxa vara deformity developed in only one case in which the screws were improperly applied. This seems to be the method of choice in the patients who can safely undergo an anesthetic and an operation.

#### SUMMARY

1. Trochanteric fractures of the femur, while not as difficult to treat as neck fractures, present special problems which are just as worthy of attention.

2. Trochanteric fractures of the femur occur in older patients than do femoral neck fractures; they are the result of greater injury; they are attended with greater pain; and they occur more often in the right hip in males.

3. There is great diversity in the types of trochanteric fractures so that generalizations about symptoms, deformities, and treatment are seldom accurate.

4. Treatment of trochanteric fractures follows several lines: use of external splints, traction devices, or internal fixation. The relative advantages and disadvantages of each method are discussed in relation to a modern plan of treating these fractures.

5. Present-day internal fixation of trochanteric fractures offers patients greater comfort, less disability, shorter hospitalization, and less likelihood of severe systemic complications from the enforced bed rest.

#### REFERENCES

1. Anderson, R.: A New Method for Treating Fractures Utilizing the Well Leg for Countertraction, *Surg., Gynec. & Obst.* 54: 207, 1932.
2. Anderson, R., McKibbin, W. B., and Burgess, E.: Intertrochanteric Fractures: Nonoperative Castless and Ambulatory Method of Treatment, *J. Bone & Joint Surg.* 25: 153, 1943.
3. Brewster, W. R.: Fractures of the Upper Extremity of the Femur—Neck and Trochanter, *Am. J. Surg.* 42: 662, 1938.
4. Caldwell, J. A.: Subtrochanteric Fractures of the Femur, *Am. J. Surg.* 59: 370, 1943.
5. Casberg, M. A.: Use of the Lag Screw for Internal Fixation of Intertrochanteric Fractures of the Femur, *Surg., Gynec. & Obst.* 72: 772, 1941.
6. Cleary, E. W., and Morrison, G. M.: Lock-Bolt Fixation of Fractures of the Femoral Neck and of Intertrochanteric Fractures, *J. Bone & Joint Surg.* 22: 125, 1940.
7. Compere, E. L., and Banks, S. W.: *Pictorial Handbook of Fracture Treatment*, Chicago, 1943, The Year Book Publishers, Inc.
8. Cordasco, P.: Evolution of Treatment of Fracture of Neck of Femur, *Surg.* 37: 871, 1938.

9. Drutt, R.: The Principles and Practice of Modern Surgery, Philadelphia, 1852, Blanchard & Lea.
10. Dunlop, J.: The Russel Traction Method of Treating Fractures of the Femur, *Am. J. Surg.* 49: 155, 1940.
11. Hodgen, J. T.: On Fractures, *M. & S. J.* 8: 228, 1871.
12. Jewett, E. L.: One Piece Angle Nail for Trochanteric Fractures, *J. Bone & Joint Surg.* 23: 803, 1941.
13. Jones, C. P.: Intracapsular and Intertrochanteric Fractures of the Femur and Fractures of the Pelvis—Their Treatment, California and West. Med. 36: 79, 1932.
14. Key, J. A.: Internal Fixation of Trochanteric Fractures of the Femur, *SURGERY* 1: 13, 1939.
15. Leydig, S. M.: Trochanteric Fractures of the Femur, *J. Missouri M. A.* 36: 413, 1939.
16. Leydig, S. M., and Brookes, T. P.: Treatment of Pertrochanteric Fracture of the Femur With a Lag Bolt, *J. Missouri M. A.* 37: 354, 1940.
17. Lippman, R. K.: The Role of Internal Fixation With the Corkscrew Bolt in Intertrochanteric Fractures, *J. Mt. Sinai Hosp.* 7: 159, 1941.
18. Martiu, E. D., and King, A. C.: Preliminary Report of a New Method of Treating Fractures of the Neck of the Femur, *New Orleans M. & S. J.* 75: 710, 1922.
19. Moore, A. T.: Fracture of the Hip Joint, *Surg., Gynec. & Obst.* 64: 420, 1937.
20. Moore, A. T.: Personal Communication.
21. Moore, A. T.: Blade Plate Internal Fixation for Intertrochanteric Fractures. (In Press.)
22. Morris, H. D.: Trochanteric Fractures, *South. M. J.* 34: 571, 1941.
23. McKibbin, W. B.: Trochanteric Fractures of the Femur, *Northwest Med.* 40: 242, 1941.
24. McKibbin, W. B.: An Ambulatory Method of Treatment for Intertrochanteric Fractures of the Femur, *Surg., Gynec. & Obst.* 76: 343, 1943.
25. Overton, L. M.: Personal Communication.
26. Preston, M. E.: Fractures and Dislocations, St. Louis, 1915, The C. V. Mosby Co.
27. Russell, R. H.: Theory and Method in Extension of the Thigh, *Brit. M. J.* 2: 637, 1921.
28. Stimson, L. A.: A Practical Treatise on Fractures and Dislocations, New York, 1910, Lea & Febiger.
29. Thatcher, H. V.: An Internal Fixation Device for the Treatment of Intertrochanteric Fractures of the Femur, *Am. J. Surg.* 60: 44, 1943.
30. Thornton, L.: The Treatment of Trochanteric Fractures: Two New Methods, *Piedmont Hosp. Bull.* 10: 21, 1937.
31. Thornton, L.: Personal Communication.
32. Urist, M.: Personal Communication.
33. Venable, C. S., and Stuck, W. G.: Vitallium Nails in Fracture of the Hip, *Surg., Gynec. & Obst.* 70: 964, 1940.
34. Wendel, A.: Extracapsular Fractures of the Femur in the Aged: Merits of the Russell Treatment, *J. Bone & Joint Surg.* 13: 616, 1931.
35. Wilkie, D. P. D.: The Treatment of Fracture of the Neck of the Femur, *Surg., Gynec. & Obst.* 44: 529, 1927.
36. Wilson, P. D.: Management of Fractures and Dislocations, Philadelphia, 1940, J. B. Lippincott Company.

# HEPATOMA IN INFANCY AND CHILDHOOD

## DISCUSSION AND REPORT OF PATIENT TREATED BY OPERATION

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REPORTS of primary tumors of the liver in children have appeared in the literature, although infrequently. Most of these are autopsy reports. The surgical removal of liver tumors has also been recorded a number of times, although most of these removals have been in adults. When, during the course of an exploratory laparotomy in a 13-month-old baby, a huge tumor was found imbedded in the liver, the question immediately arose as to the feasibility of removal. The report of this case and the review of similar cases in the literature would seem to be of some value in future decisions.

### CASE REPORT

C. E. L., male, aged 13 months (Children's Hospital No. 41-8173), was admitted Dec. 24, 1941. The following history was obtained from the mother. The patient was the first and only child. He was said to be a "blue baby" at birth with typical resuscitation. Birth was at full term, weight  $7\frac{1}{2}$  pounds. He was jaundiced immediately post partum and remained so for two or three weeks. He was well after this until July 1, 1941, when he developed whooping cough. Prior to onset of the cough he weighed approximately 20 pounds. He started losing weight immediately. His skin became pasty and by August, 1941, he weighed about 14 pounds. That same month the parents noticed a mass in the upper abdomen on the right side, about the size of an egg. The mass, except for some recessions, grew steadily. He was constipated after the onset of the whooping cough. No jaundice was noticed since three weeks after birth. A low-grade fever was suspected for months.

On admission the baby was thin and sallow. He had a temperature of  $100.4^{\circ}$  F. Weight was 15 pounds. The anterior fontanel was open and all sutures were separated. The left ear drum was injected and bulging, the right showed evidence of spontaneous rupture. There was a nasal discharge. One tooth was present. Heart showed possibly a slight enlargement with a short loud systolic murmur. Lungs were entirely clear. The abdomen was soft and the liver edge was felt about 3 cm. below the costal margin. A rounded firm mass filled the right side of the abdomen and extended to the flank and iliac crest. It could not be determined whether the liver edge overlapped this mass or merged with it. The mass moved with the liver.

Blood showed 65 per cent hemoglobin; 3,620,000 red corpuscles with 4 nucleated cells per 100; 12,600 white blood cells with 62 per cent polynuclears; coagulation time was three minutes. Urine was not remarkable.

A flat plate of the abdomen showed a mass on the right without definite outline of the right kidney (Fig. 1). Barium enema was negative except for a very low

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hepatic flexure and pressure signs on the cecum with displacement to the left (Fig. 2). After diodrast compound was given intravenously, no abnormality could be found in the left kidney although filling was not complete. While filling of the right kidney calyces and ureter was only partial, there was no definite evidence of abnormality.

A transfusion of 100 c.c. of blood was given December 31. On Jan. 2, 1942, exploratory laparotomy revealed a large rounded tumor protruding from, but deeply embedded in, the right lobe of the liver. It was of firm consistency and covered with large blood vessels. Search of the rest of the abdomen revealed no other tumor. The liver tumor was roughly encapsulated and could be peeled out of the liver, but with profuse bleeding which was controlled by deep encircling sutures and a rubber dam-covered gauze pack. A transfusion of 50 c.c. of blood was added that day and another of 100 c.c. two days later.



Fig. 1.—Flat plate of abdomen before operation, showing shadow of tumor and displacement of intestine.

Convalescence was satisfactory until seven days later, when a moist wound followed by protrusion of omentum occurred. From then on, for two weeks, the condition of the child was not good, there were signs of sepsis, and it was not until February 15, that the child was dismissed from the hospital. He was then in good condition and gaining rapidly.

Reports obtained from the parents from time to time showed normal growth and progress. In April, 1943, he visited the hospital at the request of the social service. He was well nourished and looked healthy, his weight was 30 pounds, his incisional scar was solid, and the liver could be felt well below the costal margin. X-ray no longer showed the low position of the hepatic flexure. (Fig. 3.)

some areas had a clear faintly reticular cytoplasm, while in others the cytoplasm was granular, slightly eosinophilic. Empty intracytoplasmic vacuoles suggesting fatty metamorphosis appeared in many cells. Mitotic nuclear divisions were present but not numerous. Central veins and portal radicles were identifiable but did not bear a constant relationship to each other. The number of small ducts was larger than in the normal liver, and their arrangement was less uniform. The green streaks noted grossly represent some of these ducts which contain bile pigment, although none appeared in the tumor cells or in the larger bile ducts.

*Pathologic Diagnosis.*—Liver cell adenoma (hepatoma).

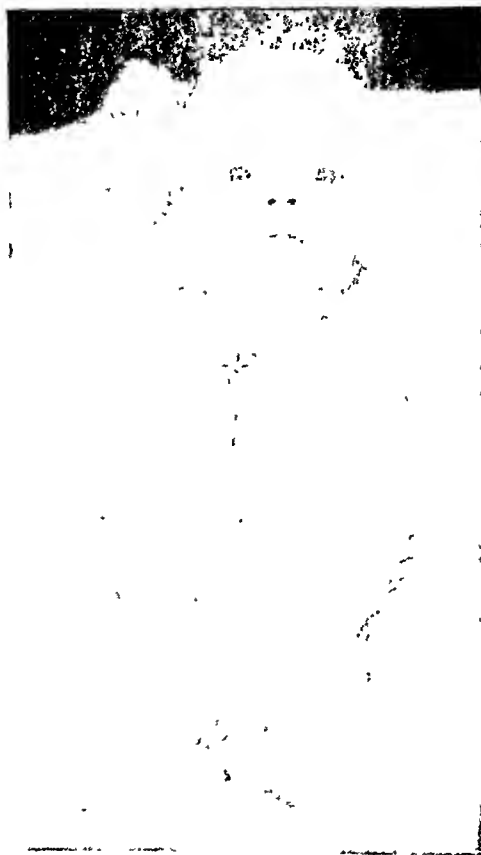


Fig. 1.—Photograph of patient four weeks after operation; general weight appearance about as before operation.

Ewing<sup>1</sup> discusses primary epithelial tumors of the liver in some detail. He classifies them as (1) hepatoma, under which heading he puts (a) solitary adenoma or solitary hepatoma, (b) primary massive liver cell carcinoma, (c) multiple liver cell carcinoma or hepatoma, and (d) carcinomatous cirrhosis or multiple adenoma, carcinoma, or hepatoma; and (2) cholangioma or tumors of the bile ducts. The tumor here reported apparently comes under the head of (1a) solitary adenoma or hepatoma. Many of these, Ewing states, appear in early life, from 3 months of age or later, and are therefore probably to be regarded as



of congenital origin. He adds that a congenital maladjustment of groups of liver cells predisposing them to tumor growth, although a rare factor in adults, is possibly of importance in infants with solitary tumors.

Ewing's description of a projecting and encapsulated tumor, gray to yellow, composed of cords in arrangement closely resembling liver structure, granular cells, and some fatty, the veins not invaded, corresponds closely to the findings in this case. He considers that while the veins are not invaded, the benign character is due chiefly to the encapsulation and that transitional forms to adenocarcinoma occur in which there are invasion of veins and multiplication of tumors. He regards the process as essentially carcinomatous.



Fig. 5.—Photograph of patient sixteen months after removal of hepatoma.

Survey of the literature does not in many cases give a clear distinction between benign and malignant hepatoma. In 1918, Griffith<sup>2</sup> collected from the literature 57 cases of what he considered primary carcinoma of the liver in infants and children. In only one was removal attempted, and that unsuccessfully. Dansie,<sup>3</sup> in his report of a case in 1922 found 23 cases of primary growth of the liver up to  $2\frac{1}{2}$  years, most of these being in the first six months. No cures were noted.

Shaw,<sup>4</sup> in 1923, reported the successful removal of a 2 pound 3 ounce tumor from the liver of a boy 13 years of age. He considered his case a hepatoma and described his tumor as an encapsulated liver cell tumor with aberrant character of cells pointing to a certain, but not high, degree of malignancy. He felt that this case, like many others, represented a stage of transformation of a simple adenoma to a definitely carcinomatous liver tumor. If such a case is allowed to go on he believes there will be secondary nodules in the liver itself and in time gross tumor thrombi in the portal vein and hepatic veins with metastases beyond.



Fig. 6—Gross appearance of tumor.

Kilfoy and Terry,<sup>5</sup> in 1929, commented on the rarity of primary liver cell tumor in early life and could find only 44 cases in patients between the ages of 1 day and 16 years sufficiently authenticated to include in their report. Their own case showed a solid carcinoma 6 cm. across consisting of groups of polygonal or spherical cells in a dense connective tissue framework without gland or duct formation, and separated in general from the liver by bands of connective tissue. There were retroperitoneal and lung metastases.

Three cases in early life of primary liver tumor consisting of polyhedral to spherical cells in general liver arrangement were reported by Pirie,<sup>6</sup> in 1932. All were considered primary carcinomas of the liver. One patient, aged 8 months, died without operation, another, aged 8 months, died after exploration with biopsy, and a third, aged 11 years, who survived the removal of a pedunculated mass weighing 220 Gm was living and well two years later. This tumor had obviously not extended beyond its encapsulation.



Fig 7—Section of the hepatoma showing a fibrous septum and solid masses of tumor cells with clear cytoplasm ( $\times 125$ ).

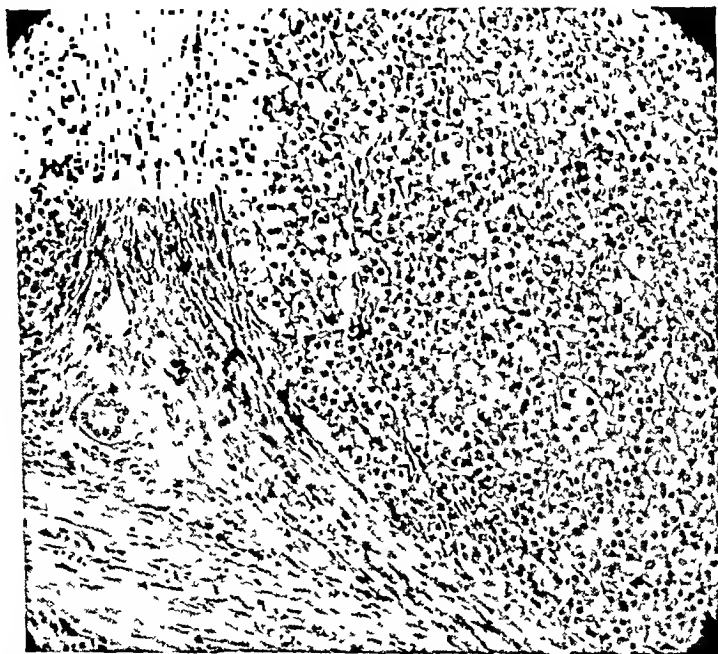


Fig 8—Section showing a septum and bile duct. Some of the adjoining tumor cells have granular cytoplasm ( $\times 125$ ).

Treatment is based on pressure symptoms and malignant possibilities. It may be that many small tumors remain so throughout life and are never found. Spreading and metastasizing tumors are very seldom removable. As all these hepatomas, no matter how benign appearing, are potentially malignant, they should be removed, preferably with a margin of liver tissue.<sup>24</sup> The treatment is exclusively surgical. The risk of surgery naturally depends upon the size and extent of the tumor. Wallace,<sup>24</sup> for example, found 29 patients with resectable hepatoma, of which 23 survived operation. Eight of the 20 had a recurrence. Twelve are known to be alive and well, two to five years after operation.

The surgical removal of liver tumor is often dismissed as not feasible, but an astonishingly large number of successful operations have been reported. No attempt will be made to cover them all, but some illustrating the various techniques will be mentioned. As far back as 1899, Keen<sup>26</sup> reported his third case of removal of a liver tumor. Two of the tumors, an adenoma and a carcinoma, were removed with the cautery, the larger vessels tied, and a gauze packing inserted, while the other, an angioma, was brought out extraperitoneally, constricted by an elastic ligature, and allowed to slough away. To go with his case report, Cushing and Downs added for him a table of 75 cases of liver tumor removal found in the literature up to that date. These showed a mortality of 14.9 per cent, gave ages from 21½ days to 77 years, and included herniated lobe, syphiloma, carcinoma, adenoma, sarcoma, angioma, hydatid cyst, and others more rare.

Yeomans,<sup>27</sup> in 1915, reported the removal of a carcinoma of the liver by curettage without evidence of recurrence for seven years. Grey Turner,<sup>28</sup> in 1923, reported the removal of a large tumor from the right lobe of the liver. Interlocking heavy catgut sutures on large fully curved intestinal needles were placed preceding the V-shaped resection. Some hepatic artery branches were also tied. The sides of the V could then be approximated by four through-and-through catgut sutures. One area not quite closed was packed with rubber-protected gauze. This tumor was a true liver cell tumor, a hepatic adenoma with cells more aberrant than usually found. When seen twenty-two months later, the patient appeared well.

Wright,<sup>25</sup> in 1923, reported the successful removal of a tumor the size of an orange with a small neighboring nodule from the liver of a man 60 years of age. The pathologic report showed primary carcinoma of the liver; there was an excellent capsule except at a few places. He advised the shelling out or bold cutting of the liver without the preliminary placing of interlocking sutures, the use of a hot pack, and then the picking up of individual vessels. He was unable to approximate the edges in this case and used a gauze pack.

A malignant tumor of the gall bladder infiltrating the liver was reported by Frankan,<sup>29</sup> in 1923. He removed with scalpel the gall blad-

der, a wedge of liver 3 inches wide at the base,  $3\frac{1}{2}$  inches deep, and over 2 inches thick at the deepest part of the incision. As sutures did not stop the brisk hemorrhage, he brought up a large fold of great omentum in a double layer which he inserted into the liver incision. Sutures were then passed through the omentum and liver with good coaptation of the cut edges and gave complete hemostasis. That part of the omentum was then cut off. He has used omentum in other cases of torn or cut liver and found this hemostatic method most satisfactory. His patient when last seen, 15 months after operation, was doing well.

Philip Turner<sup>10</sup> removed with the cautery an adenoma of the liver which had previously ruptured and was still bleeding, but his patient died one hour later. Kidd,<sup>31</sup> at the same meeting, reported the wedge removal of an adenoma after first placing sutures with Cullen's blunt needles. In the discussion of this case, Walton<sup>31</sup> described his method. An assistant should evert the liver and strongly grasp it on either side with his hands. With the hemorrhage thus under control, the tumor may be removed partly by excision, partly by enucleation. He then uses wide mattress sutures of large catgut through either side to grasp the liver tightly. When tied, the gaps in the approximation may be closed by additional sutures passed under the loops of the mattress sutures, the combination controlling the hemorrhage completely.

Nitch,<sup>32</sup> in 1923, removed a tumor of the lingual lobe. The area was clamped, resected, and then closed with mattress sutures. Hicks,<sup>33</sup> in 1929, reported the successful removal of a carcinoma of the liver in a man 77 years of age, using sharp dissection and sewing the gap as cut with interlocking catgut sutures, then employing a rubber glove for tamponage and drainage. The removal of a large pedicled adenoma by Schrager,<sup>21</sup> reported in 1937, represents the occasional type not requiring special methods of hemostasis.

Abel,<sup>34</sup> in 1933, reported the removal of most of the left lobe of the liver for a large primary carcinoma. He placed chain ligatures before removal, with some ties afterwards. Love,<sup>35</sup> in 1934, reported the removal of the whole left lobe after finding the pedicle and tying the hepatic artery and portal vein branches. The mass was the size of a coconut, which was later diagnosed hepatoma. Death from metastases occurred two months later. Jackson<sup>36</sup> had previously reported the removal of most of the left lobe after ligation of the left hepatic artery and the corresponding veins. His patient, aged 80 years was well seventeen months later.

Cattell,<sup>37</sup> in 1940, in his reported removal of a metastatic nodule from the right lobe of the liver made a large V-shaped incision to include the mass which was over three inches in diameter. The bleeding was controlled by the slow coagulating current and by separate ligatures of the larger vessels. The defect was closed by interrupted catgut sutures after freeing the left lobe to allow more mobility.

Wallace,<sup>24</sup> in an excellent review of the subject of hepatoma in 1941, described the removal of such a tumor from the right lobe. After a series of overlapping mattress sutures through normal liver, the tumor with the gall bladder attached was removed by a wedge-shaped incision with a sharp knife through normal tissue, the mattresses were tied, and the raw edges closed with a running suture.

Benson and Penberthy<sup>14</sup> accomplished their removal of a 60 Gm. tumor in a child by making a wedge-shaped excision with a cautery knife and closing this with sutures after placing omentum in the gap.

The subject of surgical technique has been quite thoroughly presented by Walton<sup>31</sup> and later studied by Tinker and Tinker.<sup>38</sup> The latter point out that the lobes and subdivisions of the liver are supplied by independent arteries so that one section can be removed without injury to the remaining sections, that anastomoses are free so that if the blood supply to a part is removed there may still be adequate circulation, and that regeneration after removal of liver substance is rapid and quite complete. Mann<sup>39</sup> also, in his experimental surgery, has shown the tremendous regeneration power of the liver and the technique of left lobe removal.

Methods used for liver tumor removal by the authors quoted are varied but follow a few general principles. (1) The tumor or that part of the liver may be delivered into the wound and exteriorized. Pins like knitting needles may be used to hold it in place if desired; sometimes an elastic tourniquet is used. Separation may require two weeks or so and it takes many weeks for the stump to heal over. This method has been described mostly in the earlier reports. (2) There has been wide use of a low-heat cautery or a cautery knife with tying of the larger vessels. This seems less in favor perhaps than formerly, but is probably necessary for some types. (3) First placing deep mattress sutures or interlocking sutures in normal tissues, then cutting out the wedge and tightening the already placed sutures followed by an additional running suture to close the free edge may be considered a standard method. It depends on close opposition plus mattress type of suture to control bleeding and sounds ideal for the usual large wedge resections. (4) The tight holding of the free liver edge by an assistant while the wedge is cut out and then tying individually or by through-and-through sutures is practicable for some cases. Whenever possible, permanent arrest of hemorrhage by mattresses or individual ties is the best. It is often possible to tie the branches of the hepatic artery and to encircle the large venous channels. The capsule is the only tough part of the liver that holds at all which makes some mattress type of suture usually necessary. Simple approximation takes care of the smaller wedges. If approximation cannot be accomplished, then approximation over gauze, rubber dam, or omentum must be substituted to gain hemorrhage control. If temporary clamping or holding of the main blood supply at the free edge of the lesser omentum is employed, it must be very brief as it causes

a dangerous drop in blood pressure.<sup>33</sup> Clamps on the liver itself are not, as a rule, satisfactory; temporary tourniquet use is not often practicable.

### CONCLUSIONS

1. A case is reported of successful removal of a large hepatoma, showing some suggestions of early malignancy without evidence of recurrence after fifteen months.
2. The literature reveals that the benign adenoma or hepatoma does not by any means remain benign and may destroy by pressure if of large size or by malignant extension.
3. Treatment is exclusively surgical; the standard techniques of liver tumor removal are reviewed.
4. The experiences of various surgeons with this problem are reported.

### ADDENDUM

A letter from the University of Nebraska Hospital, dated January, 1944, states that this same patient was admitted there Nov. 11, 1943, for abdominal tumors. Exploration showed a normal right lobe of the liver but a left lobe full of tumor nodules. A small piece taken from one of these nodules was diagnosed carcinoma of the liver (hepatoma type). The tissue was considered after comparison very similar to that removed here in January, 1942.

### REFERENCES

1. Ewing, J.: *Neoplastic Diseases*, Ed. 4, Philadelphia, 1940, W. B. Saunders Company, pp. 735-748.
2. Griffith, J. P. C.: Primary Carcinoma of the Liver in Infancy and Childhood, *Am. J. M. Sc.* 155: 79, 1918.
3. Dansie, C. B.: Primary Malignant Growth of Liver in Infants. Report of Recent Case, *Lancet* 2: 228, 1922.
4. Shaw, A. F. B.: Primary Liver Cell Adenoma (Hepatoma), *J. Path. & Bact.* 26: 475, 1923.
5. Kilfoy, E. J., and Terry, M. C.: Primary Carcinoma of the Liver in Childhood, *Surg., Gynec. & Obst.* 48: 751, 1929.
6. Pirie, G. R.: Primary Carcinoma of the Liver in Infants and Young Children, *Canad. M. A. J.* 27: 401, 1932.
7. Kordenat, R. A.: Primary Carcinoma of the Liver in Infancy, *Am. J. Digest. Dis.* 1: 60, 1934.
8. Ducas, P., and Albot, G.: Les Epitheliomas Primitifs du Foie chez l'Enfant, *Arch. de méd. d. enf.* 36: 595, 1933.
9. Hagaman, G. H.: Primary Carcinoma of the Liver. Report of a Case in a 6 Months Old Infant, *Minnesota Med.* 17: 40, 1934.
10. Steiner, M. M.: Primary Carcinoma of the Liver in Childhood. Report of 2 Cases With a Critical Review of the Literature, *Am. J. Dis. Child.* 55: 807, 1938.
11. Noeggerath, E. (Cited by Steiner<sup>10</sup>): Geburtshindernis in Folge eines Lebercarcinoms beim Neugeborenen, *Deutsche klin.* 6: 496, 1854.
12. Wilens, G.: Adenoma of the Liver, *Am. J. Dis. Child.* 55: 792, 1938.
13. Charache, H.: Primary Carcinoma of the Liver, *Am. J. Surg.* 43: 96, 1939.
14. Benson, C. D., and Penberthy, G. C.: Surgical Excision of Primary Tumor of Liver (Hamartoma) in Infant of Seven Months With Recovery, *SURGERY* 12: 881, 1942.
15. Drummond, C. H., and Tollman, J. P.: Primary Carcinoma of the Liver in a Child. Case Report, *Am. J. Clin. Path.* 9: 361, 1939.
16. Webster, R.: Malignant Hepatoma in Infancy, *M. J. Australia* 2: 381, 1938.
17. Jenks, A. L., Powell, L. D., and Kaump, D. H.: Primary Carcinoma of the Liver With Spontaneous Rupture, *J. Iowa M. Soc.* 29: 193, 1939.

18. Wentz, V. B., and Kato, K.: Primary Carcinoma of the Liver With Banti's Syndrome, *J. Pediat.* 17: 155, 1940.
19. Rolleston, H. D.: *Diseases of the Liver, Gall Bladder and Bile Ducts*, Philadelphia, 1905, W. B. Saunders Company.
20. Pepere, A. (Cited by Schrager<sup>21</sup>): *Arch. per le Sc. Med.* 26: 117, 1902.
21. Schrager, V. L.: Surgical Aspects of Adenoma of the Liver, *Ann. Surg.* 105: 33, 1937.
22. Glenn and Byrne (Cited by Hoffmau<sup>23</sup>): Hepatoma With Late Dissemination, *J. Missouri M. A.* 30: 142, 1933.
23. Hoffman, H. S.: Benign Hepatoma; Review of the Literature and Report of a Case, *Ann. Int. Med.* 17: 130, 1942.
24. Wallace, R. H.: Resection of Liver for Hepatoma, *Arch. Surg.* 43: 14, 1941.
25. Wright, G.: Primary Carcinoma of the Liver Excised by Operation, *Proc. Roy. Soc. Med.* 16: 56, 1923.
26. Keen, W. W.: Report of a Case of Resection of the Liver for the Removal of a Neoplasm With a Table of 76 Cases of Resection of the Liver for Hepatic Tumors, *Ann. Surg.* 30: 267, 1899.
27. Yeomans, F. C.: Primary Carcinoma of the Liver, *J. A. M. A.* 64: 1301, 1915.
28. Turner, G. G.: A Case in Which an Adenoma Weighing 2 lb. 3 oz. Was Successfully Removed From the Liver: With Remarks on the Subject of Partial Hepatectomy, *Proc. Roy. Soc. Med. (Dept. Surg.)* 16: 43, 1923.
29. Frankan, C.: A Case of Resection of the Liver for Malignant Disease Spreading From the Gall Bladder, *Proc. Roy. Soc. Med. (Dept. Surg.)* 16: 59, 1923.
30. Turner, P.: Case of Excision of an Adenoma of the Liver Which Had Ruptured Spontaneously Causing Internal Hemorrhage, *Proc. Roy. Soc. Med. (Dept. Surg.)* 16: 60, 1923.
31. Kidd, F.: Case of Primary Tumor of the Liver Removed by Operation, *Proc. Roy. Soc. Med. (Dept. Surg.)* 16: 61, 1923.
32. Nitch, C. A. R. (Cited by Charache<sup>13</sup>): *Lancet* 1: 334, 1923.
33. Hicks, E. S.: Removal of a Primary Carcinoma of the Liver, *Canad. M. A. J.* 20: 169, 1929.
34. Abel, A. L.: Primary Carcinoma of the Liver With Report of Case Successfully Treated by Partial Hepatectomy, *Brit. J. Surg.* 21: 684, 1933.
35. Love, R. J. McN.: Primary Carcinoma of the Liver. Successful Lobectomy, *Brit. J. Surg.* 22: 387, 1934.
36. Jackson, R. H. (Cited by Charache<sup>13</sup>): *Tr. South. S. A.* 44: 299, 1931.
37. Cattell, R. B.: Successful Removal of Liver Metastasis From a Carcinoma of Rectum, *Lahey Clin. Bull.* 2: 7, 1940.
38. Tinker, M. B., and Tinker, M. B., Jr.: Resection of the Liver; Conditions Favorable for Operation; Methods; Experimental Studies, *J. A. M. A.* 112: 2006, 1939.
39. Mann, F. C.: The Portal Circulation and Restoration of the Liver After Partial Removal, *SURGERY* 8: 225, 1940.



## COMMENTS ON ILEOCOLOSTOMY AND INTESTINAL EXCLUSION

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THE perforation of a carcinoma of the cecum after an ileocolostomy—the first operation of a two-stage procedure for the removal of the tumor—drew our attention to the problems encountered when procedures for intestinal exclusion are performed. Little has been written on this subject, although a voluminous literature deals with the technique of surgery of the large bowel. For this reason we would like to report a group of experiments and present records of several cases that illustrate some of the physiologic principles of surgery of the large intestine. It may be said that these observations are concerned primarily with lesions of the lower end of the ileum and right half of the large bowel and since these lesions may be treated either by single or by multiple-stage procedures, the conclusions arrived at may help in the proper planning of operative therapy.

During the past ten years, twenty-nine patients at the New York Hospital have been subjected to some type of operation for intestinal exclusion (exclusive of colostomy), performed during the course of treatment for malignant or nonmalignant diseases. Four of these patients had complications that are reported in detail as illustrations of important principles that we should like to emphasize.

Fifty years ago much thought was given to the methods of intestinal exclusion and Senn,<sup>1</sup> and later Hartman,<sup>2</sup> reported a series of experiments on so-called physiologic exclusion in which its value in the end treatment of certain types of intestinal obstruction was emphasized. With the progress of surgery, methods of exclusion have been replaced by methods of removal and, as a result, little has been written in the past forty years on principles of intestinal exclusion. However, in the present accepted methods of treatment, physiologic exclusion frequently is performed as one part of a multiple-stage procedure, or as a palliative operation, in spite of the fact that one-stage removal of right-sided lesions is becoming the custom and has been made safer with the use of the sulfonamides and such adjunct measures as the Miller-Abbott tube.

A multiple-stage removal of a right-sided lesion in the large bowel is indicated when (1) complete obstruction is present (a very rare occurrence), (2) when the lesion is fixed as a result of associated infection,

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18. Wentz, V. B., and Kato, K.: Primary Carcinoma of the Liver With Banti's Syndrome, *J. Pediat.* 17: 155, 1940.
19. Rolleston, H. D.: *Diseases of the Liver, Gall Bladder and Bile Ducts*, Philadelphia, 1905, W. B. Saunders Company.
20. Pepere, A. (Cited by Schrager<sup>21</sup>): *Arch. per le Sc. Med.* 26: 117, 1902.
21. Schrager, V. L.: Surgical Aspects of Adenoma of the Liver, *Ann. Surg.* 105: 33, 1937.
22. Glenn and Byrne (Cited by Hoffman<sup>23</sup>): Hepatoma With Late Dissemination; *J. Missouri M. A.* 30: 142, 1933.
23. Hoffman, H. S.: Benign Hepatoma; Review of the Literature and Report of a Case, *Ann. Int. Med.* 17: 130, 1942.
24. Wallace, R. H.: Resection of Liver for Hepatoma, *Arch. Surg.* 43: 14, 1941.
25. Wright, G.: Primary Carcinoma of the Liver Excised by Operation, *Proc. Roy. Soc. Med.* 16: 56, 1923.
26. Keen, W. W.: Report of a Case of Resection of the Liver for the Removal of a Neoplasm With a Table of 76 Cases of Resection of the Liver for Hepatic Tumors, *Ann. Surg.* 30: 267, 1899.
27. Yeomans, F. C.: Primary Carcinoma of the Liver, *J. A. M. A.* 64: 1301, 1915.
28. Turner, G. G.: A Case in Which an Adenoma Weighing 2 lb. 3 oz. Was Successfully Removed From the Liver: With Remarks on the Subject of Partial Hepatectomy, *Proc. Roy. Soc. Med. (Dept. Surg.)* 16: 43, 1923.
29. Frankan, C.: A Case of Resection of the Liver for Malignant Disease Spreading From the Gall Bladder, *Proc. Roy. Soc. Med. (Dept. Surg.)* 16: 59, 1923.
30. Turner, P.: Case of Excision of an Adenoma of the Liver Which Had Ruptured Spontaneously Causing Internal Hemorrhage, *Proc. Roy. Soc. Med. (Dept. Surg.)* 16: 60, 1923.
31. Kidd, F.: Case of Primary Tumor of the Liver Removed by Operation, *Proc. Roy. Soc. Med. (Dept. Surg.)* 16: 61, 1923.
32. Nitch, C. A. R. (Cited by Charache<sup>13</sup>): *Lancet* 1: 334, 1923.
33. Hicks, E. S.: Removal of a Primary Carcinoma of the Liver, *Canad. M. A. J.* 20: 169, 1929.
34. Abel, A. L.: Primary Carcinoma of the Liver With Report of Case Successfully Treated by Partial Hepatectomy, *Brit. J. Surg.* 21: 684, 1933.
35. Love, R. J. McN.: Primary Carcinoma of the Liver. Successful Lobectomy, *Brit. J. Surg.* 22: 387, 1934.
36. Jackson, R. H. (Cited by Charache<sup>13</sup>): *Tr. South. S. A.* 44: 299, 1931.
37. Cattell, R. B.: Successful Removal of Liver Metastasis From a Carcinoma of Rectum, *Lahey Clin. Bull.* 2: 7, 1940.
38. Tinker, M. B., and Tinker, M. B., Jr.: Resection of the Liver; Conditions Favorable for Operation; Methods; Experimental Studies, *J. A. M. A.* 112: 2006, 1939.
39. Mann, F. C.: The Portal Circulation and Restoration of the Liver After Partial Removal, *SURGERY* 8: 225, 1940.

W., a 39-year-old white man, was admitted to the hospital because of a palpable tumor in the right lower quadrant of six months' duration, and abdominal cramps and vomiting of two days' duration.

Examination revealed a pale, undernourished man whose abdomen was slightly distended. A tender, palpable mass was present in the right lower quadrant. Hemoglobin was 68 per cent; red blood cells, 4.6 million; white blood cells, 6,800. The diagnosis was carcinoma of the cecum.

After three days of supportive therapy, an ileocolostomy in continuity (Fig. 1) was done. The postoperative course was uneventful until the fifteenth day, when fever developed and rose progressively over the next ten days. Four weeks after the ileocolostomy, the second stage was done with great difficulty because of the presence of a large abscess at the site of perforation of the tumor. The postoperative course was stormy and complicated by a fecal fistula. Recovery was slow but complete.

The failure to divide the ileum in this patient probably prevented subsidence of infection of the tumor and led to subsequent perforation and abscess formation. Although the patient recovered, the removal of the tumor was done with difficulty and was followed by a stormy postoperative course and temporary fecal fistula.

C., a 52-year-old man, was admitted to the hospital because of weakness and fatigue of seven months' duration, and a mass in the right lower quadrant of the abdomen of two weeks' duration. There had been a loss of ten pounds in weight and intermittent diarrhea.

The patient was pale and undernourished. There was a hard, slightly tender mass in the right lower quadrant. Hemoglobin was 88 per cent; red blood cells, 3.5 million; white blood cells, 10,000. The diagnosis was carcinoma of the cecum.

After two weeks of supportive therapy, an ileocolostomy in continuity (Fig. 1) was done. The postoperative course was complicated by a mild fever during the first five days. On the eighth postoperative day the patient developed abdominal pain and high fever and after a rapidly progressive downhill course, died on the twelfth postoperative day. Post-mortem examination revealed a perforated carcinoma of the cecum with generalized peritonitis.

Failure to divide the ileum and divert the fecal stream again probably led to perforation and to the death of the patient.

Another advantage gained by dividing the ileum at the initial operation is the simplification of the second stage, since, not only has division of the ileum (a necessary step after ileocolostomy in continuity) been accomplished, but also the operative procedure can be completed without disturbing the previously made ileocolostomy.

The objection raised to division of the ileum is that the distal end of the divided ileum (Fig. 2A) may open, resulting in peritonitis. Our experience both clinically and experimentally disproves this objection. There were nine patients who had ileocolostomy with division of the ileum (Fig. 2) without complication, in contrast to thirteen patients with ileocolostomy in continuity (Fig. 1), with two complications as detailed previously. In eight animals an ileocolostomy was done as shown in Fig. 2. The distal segment of ileum and right half of the large bowel (A to B) became shrunken and atrophic. The animals were asymptomatic.

In the rare patient with complete obstruction, the ileum should be divided and the distal end may be brought up through the abdominal wall as a safety vent. However, a safety vent rarely is necessary, even with complete obstruction, and has the objection of adding technical difficulties to the second stage.

We should like to comment briefly on the technical management of the stump of ileum at the site of the ileocolostomy. As has been emphasized before, it is important that no ileum be allowed to remain distal to the anastomosis, since such an ileal pouch may perforate or become gradually distended to a size that produces symptoms of indigestion, abdominal pain, and distension. Our experiments merely corroborate this accepted fact. The following summary of a patient's record illustrates a complication that may occur when excessive ileum remains at the site of the ileocolostomy.

K., a 50-year-old white woman, was admitted to the hospital in March, 1935. In 1913, the patient had had the right half of the colon removed and an ileocolostomy performed for an obstructing lesion of the ascending colon.

For the past ten years the patient had had vague abdominal pain associated with occasional bouts of diarrhea.

For six months before admission, abdominal pain had been more or less constant, diarrhea had been frequent, and there had been loss of both weight and strength.

Except for marked pallor the general examination was negative. The abdomen was distended and visible peristalsis was present. Hemoglobin was 40 per cent; white blood cells, 8,000; red blood cells, 217 million.

A gastrointestinal roentgen series revealed partial intestinal obstruction in the region of the terminal ileum.

At operation a distended, blind pouch of ileum, measuring ten inches in length, was found at the site of the previous ileocolostomy. Simple removal of this pouch resulted in a complete cure. The patient was asymptomatic and the blood picture was normal two years postoperatively.

At times there is a question as to the type of palliative procedure that should be used for inoperable lesions of the right half of the colon. Probably, ileocolostomy in continuity is the procedure of choice, since in some cases the lesion may eventually completely obstruct the large bowel.

There has been some difference of opinion as to whether an ileocolostomy should be performed in iso- or antiperistaltic fashion. It was found that if the ileocolostomy was done in isoperistaltic fashion (Fig. 4A) the distal segment of ileum was less likely to fill with an accumulation of intestinal contents, and generally dogs in these experiments fared better than when they were subjected to an antiperistaltic anastomosis (Fig. 4B).

On rare occasions it is necessary to leave a segment of large bowel distal to a colostomy. Whereas a blind segment of small bowel distal to an ileocolostomy may be well tolerated for a limited period of time, this is not true of the large bowel. If it is necessary to leave a segment of large bowel distal to a colostomy, it is wiser to bring the end up through

the abdominal wall as a second colostomy opening or to bury the sutured distal end in the abdominal wall as added protection to the suture line. The following case illustrates what may happen if a closed segment of bowel is left distal to a colostomy.

O., a 51-year-old man, was admitted to the hospital because of symptoms and signs of partial obstruction of the lower large bowel.

Examination was not remarkable except for distention of the abdomen. A right transverse colostomy was performed and the patient prepared for resection of an obstructive lesion in the descending colon, demonstrated by barium enema.

At operation a large lesion of the descending colon was removed and, because of the extent of the lesion, so much of the bowel was resected that the proximal descending colon was not long enough to be sutured to the sigmoid. Accordingly, both ends of bowel were closed with the thought that at a later stage a reconstructive procedure would be done to re-establish the continuity of the bowel.

The postoperative course was uneventful until the fourth day, when suddenly the patient's condition became poor. He died within twenty hours.

Post-mortem examination revealed that the splenic end of the bowel had literally "blown out."

#### SUMMARY

1. Physiologic principles of exclusion procedures in surgery of the right half of the colon are discussed.

2. The importance of dividing the ileum when ileocolostomy is done as the initial procedure of a two-stage removal of a lesion of the right half of the bowel is emphasized.

3. The complication of pouch formation at the site of ileocolostomy is discussed.

#### REFERENCES

1. Senn, Nicholas: An Experimental Contribution to Intestinal Surgery With Special Reference to the Treatment of Intestinal Obstruction, *Ann. Surg.* 7: 264, 421, 1888.
2. Hartman, Henri: Exclusion de l'intestin, *Trav. de Chir.* 5: 61, 1907.

## TORULA INFECTION

### A REVIEW AND REPORT OF FOUR CASES

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**T**ORULA is a yeastlike organism belonging to the general class of fungi imperfecti, which multiplies by budding, does not produce ascospores, does not ferment carbohydrates, and does not produce a mycelium in tissue or culture. The organism is widely distributed in nature and has been cultivated from many plants and grasses, the bodies of numerous insects, bees' nests, pickle brine, and canned butter and milk. It is ordinarily nonpathogenic and various saprophytic or avirulent strains have been cultured from the normal skin, throat, and gastrointestinal tract of man.

It has been found pathogenic for man, involving more frequently the central nervous system and lungs, less frequently the viscera,<sup>3, 10, 16</sup> nasopharyngeal structures,<sup>1, 2, 13, 15</sup> skin,<sup>13, 19, 21, 27, 28, 32, 34</sup> lymph nodes,<sup>8, 11, 18</sup> and muscles and bones.<sup>4</sup> Frothingham<sup>12</sup> recorded the first spontaneous case in the animal kingdom in 1902; the disease being confined to the lungs of a horse. Weidman<sup>32</sup> observed a case of generalized torulosis in a horse. Weidman and Ratcliffe<sup>33</sup> reported it in one other animal, the cheetah, in which the process was generalized. Pathogenicity has been demonstrated experimentally in mice, rats, guinea pigs, rabbits, cats, and monkeys.<sup>8, 21</sup>

The nomenclature of yeast and yeastlike infections is loose and indefinite with attendant confusion. Names applied to the same or similar organisms causing the same disease picture are: *Cryptococcus hominis*; *C. histolytica*; *C. meningitidis*, *Torula histolytica*. Weidman<sup>32</sup> states that he has collected twenty pathogenic strains of the organism. The disease has been referred to as torulosis. European blastomycosis of Busse-Buschke and cryptococcosis.

It is thought that the portal of entry is usually through the upper respiratory passages and lungs, the organism having a special affinity for the tissues of the central nervous system. Invasion of this system by torula has been universally fatal. Zenker,<sup>35</sup> as early as 1861, reported a patient who died of encephal meningitis, due to a yeastlike organism, associated with a pharyngeal exudate without skin involvement. He described small granulomas and collections of pus in the meninges and brain. Freeman accepted this as a probable case of cen-

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tral nervous system torulosis. The next authentic case was reported in 1905 by von Hausemann,<sup>20</sup> also in the German literature. Rusk and Farnell,<sup>23</sup> in 1912, recorded the first two cases in this country. The morphology of the organisms and pathology of the disease remained obscure until Stoddard and Cutler,<sup>26</sup> in 1916, isolated the organism by cultural methods, animal inoculations, and histologic study of sections of tissue; described the clinical characteristics and pathologic changes; collected four cases from the literature and added two of their own. They ascribed the name *T. histolytica* to the organism. Freeman<sup>10</sup> in 1931, in an exhaustive monograph, collected forty-three cases from the literature. Levin<sup>16</sup> summarized the reported cases of central nervous system torulosis in 1937, bringing the total to sixty. Recently, Binford,<sup>3</sup> in 1941, tabulated the cases reported since Levin's summary, making a total of seventy-five. Since then there have been isolated reports of twenty-five cases, making a total of 100 recorded cases of involvement of the central nervous system by torula.

A pathologic classification of central nervous system torulosis was made by Freeman,<sup>9</sup> in 1930. He divided the disease into three types: (1) A purely meningeal form, with diffuse or granulomatous meningitis; (2) a perivascular form, with small granulomas or cysts in the cortex; (3) an embolic form, with deeply placed lesions lying chiefly in the gray matter. Clinically, the cases of involvement of the central nervous system resemble tuberculous meningitis and brain tumor more frequently, with meningitis (unqualified), encephalitis, brain abscess, dementia psychosis, and dementia paralytica simulated less frequently.<sup>3, 9, 17</sup>

Coincident involvement of the lungs occurred in nine of Levin's sixty cases, in four of Binford's fifteen cases of central nervous system torulosis, and in one of the six cases of Reeves, Butt, and Hammaek.<sup>22</sup> Reports of involvement of the lung alone are rare, and have been given by Sheppe<sup>24</sup> and Hardaway and Crawford<sup>14</sup> with an apparent recovery in the latter case.

Generalization of the mycotic process occurred in only twelve of the eighty-one collected cases of Freeman, Levin, Binford, and Reeves, Butt, and Hammaek and is usually fatal. In association with and accessory to torula infection of the central nervous system and lungs, the disease has been reported to involve nearly all the tissues and organs of the body.

There are a few cases in the literature in which the infectious process was localized and limited to certain parts of the body, and in which the torula organisms were recovered from the lesions. Brewer and Wood,<sup>4</sup> in 1906, recorded the first; the case of a man with an abscess of the muscles and bone of the spine. Evacuation, curettement, and packing with formalin dressings effected a cure. McGehee and Michelson<sup>18</sup> reported the recovery of a patient after incision and drainage of

an inguinal abscess which extended into the pelvis. This patient also received a course of potassium iodide. Alvarez<sup>1</sup> reported a red torula infection of the tongue which responded to arsphenamine and quinine. Jones<sup>15</sup> reported a torula infection involving the palate and nasopharynx which was arrested after cauterization, x-ray therapy, and the internal administration of iodides. Gill<sup>13</sup> also reported several cases of localized torulosis, one an ulcerative cutaneous lesion in the preauricular region on each side of the face which yielded to currettement, x-ray, and potassium iodide; another infection involved the orbit and paranasal sinuses, was accompanied by the presence of torula histolytica in the blood stream, and recovery followed x-ray and potassium iodide therapy. The relationship of torulosis and Hodgkin's disease has been mentioned occasionally in the literature, though not nearly as frequently as the tuberculosis-Hodgkin's disease relationship. The tissue reaction in the reticulo-endothelial system to torula is not unlike that seen in Hodgkin's granuloma in some reported instances. Attention was first called to this fact by Freeman and Weidman,<sup>11</sup> in 1923, who reported a patient who was first seen five years prior to death with enlarged lymph glands of the neck. Excision biopsy of one of these revealed Hodgkin's disease. The neck glands regressed under x-ray therapy, but at the time of his final admission he had a large discrete mass in the right axilla. He died of cerebrospinal torulosis, confirmed at autopsy. Axillary and peripancreatic lymph nodes were greatly enlarged and were not quite typical of Hodgkin's disease, although highly suggestive.

There have been three other cases reported in which Hodgkin's disease has been diagnosed by biopsy sometime before the onset of torulosis. Cabot's<sup>5</sup> patient had a prior diagnosis of Hodgkin's disease before dying of a torula meningitis with involvement of the kidney, adrenal, and lungs with coincident involvement of the spleen and bronchial and retroperitoneal lymph glands with Hodgkin's disease. During the discussion of this case, Mallory stated that it was the fourth case that he had seen of coincident torula infection and Hodgkin's disease. He added that he had seen an unpublished manuscript in which approximately eighty cases of torulosis were mentioned in about twelve of which torula and Hodgkin's disease were found together. Owen,<sup>20</sup> in 1940, and Warvi and Rawson,<sup>30</sup> in 1942, reported patients with an earlier diagnosis of Hodgkin's disease dying of torulosis.

There have been single cases reported by Smith and Crawford<sup>25</sup> and Wile<sup>34</sup> in which an early diagnosis of Hodgkin's disease was made by biopsy. The patients later died of torulosis, and review of the original slides reveal torula organisms present in the biopsy material.

In 1934, Fitchett and Weidman<sup>8</sup> reported the case of an 18-year-old negro male, who had noticed enlarged glands bilaterally in the axilla, neck, and groins for three years. Admission to the hospital was for



swelling of the face and neck, dizziness, headache, and delirium. Excision of one of the axillary nodes revealed changes suggestive of Hodgkin's disease; yeast organisms were recovered in scrapings from the cut surface, but could not be demonstrated in the stained sections. The diagnosis of torulosis was made from spinal fluid and autopsy findings. The autopsy revealed changes similar to typical Hodgkin's disease in the superficial and peribronchial lymph nodes and a mediastinal mass showing more or less loss of architecture and reticulo-endothelial hyperplasia with the presence of Dorothy Reed cells. Torulosis of the brain, meninges, kidneys, pancreas, and spleen was found. Torulae were cultured from the mediastinal mass. In comparing the histologic changes in the spleen, lymph nodes, and mediastinal mass they found the amount of reticulo-endotheliosis less in the spleen where the changes were due to torulae alone, than in the lymph nodes and mediastinal mass where the Hodgkin's characteristics were assumed.

To illustrate further the type of reaction incited in lymph nodes by the torula organisms, Watts,<sup>31</sup> in 1932, reported a patient dying of generalized torulosis, with cerebrospinal symptoms most marked, who had involvement of lymph nodes at the hilum of the spleen and near the common duct. Most of the nodes were completely replaced by fibrocaseous material. Tubercle-like structures with and without giant cells, scarring, extensive hyaline degeneration, and marked endothelial hypertrophy were present. Yeast fungi could not be found, but some giant cells contained spaces resembling the residues of organisms.

Sheppe<sup>24</sup> reported the first case of torulosis from the University of Virginia Hospital in 1924, that of a man who died of pulmonary torulosis, apparently without central nervous system involvement. In 1939, Magruder<sup>27</sup> reported three cases with involvement of the central nervous system in which the diagnosis was made ante mortem by culture and smear of the spinal fluid, associated with biopsy of the cerebral meninges and cortex in one case.

We wish to report four additional cases of torulosis, and to give a follow-up report on Magruder's third case.

#### REPORT OF CASES

CASE 1.—Mrs. E. S. (Hist. No. 60767), a white woman, aged 66 years, was admitted to the University of Virginia Hospital Sept. 10, 1936, in a semicomatose state.

The family history was pertinent to the extent that she had a son in the hospital at the time with typhoid fever. The past history was irrelevant.

Her illness began one month prior to admission to the hospital with headache, nausea, and vomiting. The symptoms had progressed with the addition of pain in the neck and back, and occasional fainting spells and chilly sensations. She had gradually become lethargic and was brought to the hospital in the semicomatose condition.

Physical examination revealed the following abnormalities: a very drowsy patient; a splotchy erythematous rash over the trunk anteriorly; a moderately stiff neck; a faint apical systolic murmur with heart size hard to determine; blood pressure

186/100, pulse rate 90 per minute, temperature 100.4° F.; absent knee jerks; suggestive bilateral Babinski; and a positive Gordon on the right.

Laboratory studies during the first two days of hospitalization were as follows. The hemoglobin was 84 per cent (Haden-Hauser), the leucocytes 8,800, and the differential count from a stained blood smear showed a normal distribution of cells. Blood Wassermann and Kahn tests were negative, the blood urea 64 mg. per 100 c.c., blood culture negative, and agglutinations with *Bacillus typhosus*, para A and B negative. The catheterized urine contained albumin, 3 plus, and microscopic examination revealed 2 to 3 white blood cells, 3 to 5 red blood cells, and an occasional granular cast. The stool specimen revealed occult blood, 3 plus. Lumbar puncture was performed and a pressure of 415 mm. of water found. The fluid was slightly cloudy, and had a slightly increased globulin content. There was a cell count of 474 cells with a predominance of polymorphonuclears. A smear and culture were negative.

A tentative diagnosis of benign lymphocytic chorionmeningitis was made.

During the first week of hospitalization a lumbar puncture was done daily with a cell count as high as 650 at one time. The lymphocytes gradually superseded the polymorphonuclears and became more abundant. For a time she gradually improved and became more alert, being able to take nourishment by mouth. She could talk, answer questions, and recognize members of her family. However, she continued to run a fever with temperatures between 100 and 101° F., and the spinal fluid continued to show a varying number of cells. After a month of slight improvement, she became very drowsy and unresponsive, and would not take nourishment. During the last two months of her illness she was given nourishment by stomach tube and intravenous infusions.

Neurologic examination during this time revealed an inability to recognize objects, motor and sensory aphasia, a coarse tremor of the arms and legs, pain and temperature sensations markedly diminished, hyperactive deep reflexes, unsustained left ankle clonus, and a suggestive Babinski sign on the left side.

Spinal taps were done in the later stages every four to five days, the last one showing a cell count of 86, with a predominance of lymphocytes. At one time the spinal fluid globulin was greatly increased and the total protein 127 mg. per 100 c.c. The colloidal gold curve indicated only meningeal irritation. The spinal fluid Wassermann was negative. The blood urea was 50 mg. per 100 c.c.

She lapsed into rather deep coma during the last month, voided and defecated in bed, and, in spite of careful nursing care, developed several bed sores. She continued to run a fever, with temperatures from 100 to 102° F. The white count varied from 11,200 to 12,600. A week before death the temperature increased somewhat and ranged from 102 to 105° F. The respirations became more labored, and physical examination showed large coarse râles throughout both lungs, but there were no signs of consolidation. She expired on Dec. 7, 1936, about four months after the onset of the illness.

An autopsy revealed chronic torula meningitis; atrophy of the brain; chronic bronchitis and bronchiectasis; confluent lobular pneumonia with bronchogenic abscesses (right lower lobe); purulent thrombosis of pulmonary vessels; acute fibrinous pleurisy; extensive decubital ulcers over buttocks and ankles; edema of legs; atrophy of organs; emphysema; generalized arteriosclerosis; scarring of myocardium and kidneys; chronic cystitis; scarring of cervix with obliteration of cervical canal; chronic endometritis; hyperplasia of femoral marrow; pigmentation of the spleen and bone marrow.

The brain weighed 1,150 Gm. and on gross examination small areas of thickening of the pia-arachnoid over the surface were revealed. These areas were a few millimeters in diameter. On section of the brain no changes were seen except those of atrophy. The spinal cord appeared normal. Microscopic examination of the brain revealed a chronic cellular exudate and marked increase in connective tissue

throughout the pia arachnoid. The cellular exudate consisted almost entirely of plasma cells, lymphocytes, monocytes, and giant cells of various sizes which contained torula. The organisms varied enormously in size and structure and usually occurred in small groups within the giant cells. They were spherical with a refractile margin and a central area which stained blue in some and red in others. None of the organisms were found in the section of the brain substance.

*Comment.*—This was a patient with torulosis of the central nervous system who died after an illness of four months. The diagnosis was made at autopsy, and would fall into Freeman's type I or the purely meningeal form. Repeated spinal fluid taps did not reveal the organism.

CASE 2.—R. T. (Hist. No. 115589), a white man, aged 26 years, was admitted to the University of Virginia Hospital Jan. 11, 1939, with the complaint of generalized weakness, headache, fever, loss of weight, and enlarged cervical glands.

The family, past, and marital histories were irrelevant.

The onset of illness had begun one and one half years prior to admission with fatigue, weakness, general malaise, and anorexia. Headaches, anemia, loss of weight, night sweats, and fever had followed shortly. The temperature of 101 to 102° F. had run in cycles lasting ten days to two weeks followed by a remission of temperature with partial remission of symptoms for two to three weeks. He had received liver and iron for his anemia, and a course of sulfanilamide of 100 tablets. Chest x rays, agglutinations for undulant fever, blood smears, and barium enema elsewhere had been negative. He had first noticed enlarged, tender glands in his neck two to three weeks prior to admission. During the course of his illness he had lost about forty five pounds in weight.

Physical examination revealed a malnourished, pale individual with very pale mucous membranes. The posterior cervical and supraclavicular lymph glands were enlarged bilaterally, some to 2 to 3 cm. in diameter. They were freely movable, slightly soft, and mildly tender. None of the other superficial lymph glands were enlarged. The liver and spleen were just palpable beneath the costal margin. There was a soft apical systolic murmur. Peripheral reflexes were hyperactive. Blood pressure was 112/68; temperature 103.6° F., and pulse rate 92 per minute.

Laboratory studies were as follows: hemoglobin 71 per cent, red cell count 4,170,000, white cell count 5,000, with the smear showing a normal distribution of cells. Wassermann and Kahn reactions, urine and stool examinations, and agglutinations for *Br. abortus* were negative. An intracutaneous brucellergin test was negative; and the opsonocytophagic reaction revealed that the patient was susceptible. X rays of the chest revealed a little calcium in the right root zone, but the lung fields and mediastinum appeared essentially normal.

The tentative diagnosis was Hodgkin's disease, and several right cervical nodes were excised for microscopic study. The report of the department of pathology was: "Capsule of lymph nodes thickened. Throughout there is complete obliteration of the usual lymphoid architecture. Follicles no longer visible. The lymphoid structures have been replaced by a disorderly array of cells of various types, including innumerable large giant cells, some multinucleated, of Dorothy Reed types. In addition one sees lymphoid cells, fibroblasts and endothelial cells, and a scattering of polymorphonuclears. There is a rather diffuse fine fibrosis throughout the nodes. Eosinophiles not present. All nodes show similar changes. *Diagnosis:* Hodgkin's disease, cervical lymph glands."

He was started on x ray therapy, and received a total of 900 R. to each side of the neck over a period of two weeks with regression in the size of the glands. He also received two blood transfusions to combat a mild secondary anemia. During the first two weeks of his hospitalization the temperature ranged from 100

to 103° F., during the latter part the temperature rose daily to about 100° F. He was discharged Feb. 5, 1939, feeling much better with instructions to return to the tumor clinic for follow-up studies.

He returned to the hospital March 7, 1939, with the following complaints: daily rise in temperature to 102° F., night sweats, anorexia, weakness, and generalized aching body pains. A persistent and constant headache was accompanied at times by vertigo, tinnitus, and transient deafness. Edema of the ankles and swelling of the abdomen of two weeks duration had been observed.

Examination at this time revealed a slightly jaundiced condition, and the patient in the same malnourished state. The lymph glands of the neck were very small, just barely palpable, and felt fibrosed and matted together. The abdomen was moderately and symmetrically enlarged with shifting dullness and a fluid wave demonstrable. The liver and spleen could be palpated two fingerbreadths below the costal margin. There was moderate edema of the feet and ankles. Chest x-ray revealed no changes from those noted at the first examination.

Laboratory studies revealed some secondary anemia, the hemoglobin 68 per cent, red cell count 3,400,000, and white cell count 4,750. The icterus index was 16, total protein 4.4 per cent, with the albumin-globulin ratio 1.1:1. Blood cultures, agglutinations for *Br. abortus*, and the brucellergin skin test were negative. The opsonocytophagic reaction was again reported as susceptible. Blood urea was 22 mg. per 100 c.c.

It was assumed that the patient had involvement of the liver and retroperitoneal nodes with the Hodgkin's process. He was started on x-ray therapy and given a total of 1050 R. to the abdomen over a period of a week. He had a persistent, swinging temperature from subnormal to 102° F. and steadily declined in strength and weight in spite of high calorie diet, vitamins, iron, and seven blood transfusions. He steadily became weaker, lethargic, and more jaundiced with the highest icterus index 127, and died April 21, 1939.

#### *Significant Autopsy Findings.—*

**Gross:** The body was that of a fairly well-developed but markedly emaciated and dehydrated white man, deeply jaundiced. The right pupil was dilated and regular, the left being about the same size but irregular. Anterior and posterior cervical lymph nodes were moderately enlarged and firm. Previous biopsy incision had healed. The abdomen was rounded somewhat with a fluid wave evident. Axillary and inguinal nodes were decidedly enlarged and firm with a tendency to be conglomerate rather than discrete. Rather marked edema of the feet and ankles was present. On opening the abdomen, the viscera were in their normal relationship and the peritoneal cavity contained approximately 1,800 c.c. of amber colored fluid. Both pleural cavities contained between 150 and 200 c.c. of the same type of fluid. Numerous old, fibrous pleural adhesions were found on the left from apex to base, laterally and posteriorly. The other general findings were unimportant.

**Lungs:** Small, patchy areas of consolidation in addition to edema were present in the lungs.

**Liver:** Weight, 2,760 Gm.; 31 by 25 by 9 cm. The capsular surface was smooth and glistening with a rather mottled, brownish-yellow appearance. On section the cut surface was firm with small alternating areas of red and yellowish color corresponding in general to the lobular markings.

**Spleen:** Weight, 885 Gm.; 25 by 12 by 6.5 cm. The capsular surface was smooth and glistening. On section, the cut surface was deep reddish purple with widely distributed, irregular, yellowish areas of firm consistency.

**Kidneys:** Each kidney weighted 250 Gm. and measured 13.5 by 7.5 by 4 cm. The capsules stripped easily, leaving a pinkish-red surface studded here and there with small yellowish flecks. On section, cut surfaces showed an essentially normal archi-

texture of cortex and medulla with the presence of many small, irregular, yellowish areas 1 to 2 mm. in diameter. These were present in both the cortex and pyramids. Both kidneys had similar changes.

*Small intestine, colon, and appendix:* Nothing significant was found except for a few small, punched out ulcerations in the terminal ileum.

*Femoral Bone Marrow:* Femoral bone marrow was pinkish red and hyperplastic in appearance.

*Lymph nodes:* Generalized enlargement of the axillary, inguinal, cervical, mediastinal, and all groups of retroperitoneal nodes was noted. Some nodes reached a diameter of 4 cm. On section they were yellowish white, very firm, and showed much scarring.

Permission for removal of the brain and neck structures was not granted.

#### *Microscopic.*—

*Heart:* The myocardium was normal except for scattered small nodules or foci consisting of groups of round cells and larger mononuclears lying in an intercellular, slightly acidophilic material. In at least two nodules were seen several yeastlike bodies although they were not definitely identified as torulae. The characteristic nodules occurred both in the ventricle and atrium.

*Aorta:* The aorta proper was normal. Just outside the adventitia was a small nodule of what seems to have been lymphoid tissue. It was replaced by scar, rather dense and containing small vascular spaces, both blood and lymph. There were granulomatous foci with mononuclears, a few polymorphonuclears, a few plasma cells, lymphocytes, and a few cells which resembled those of the Sternberg type. In many of the small lymphatic spaces there were the same mixed cells among which lay several yeast bodies.

*Lungs:* Areas of hemorrhage, edema, and early lobular pneumonia were found in the lungs; also several peribronchial nodules showing rather dense scarring with an admixture of remaining lymphocytes and many giant cells of the Sternberg type. Much pigment was present. In one or two foci, probably in lymphatics, there were small yeastlike bodies. They were difficult to identify.

*Liver:* In the liver widespread, nodular, granulomatous areas were present which appeared chiefly in the periportal regions, many having become confluent. Their cellular content consisted mainly of round cells, mononuclears, and giant cells as seen in the other organs. There were occasional eosinophiles but relatively few polymorphonuclears. No definite yeast bodies could be identified.

*Spleen:* There was widespread scarring and disturbance of architecture. Some of the same granulomatous areas were present as had been seen in the liver, but many areas showed a peculiar irregular zone of mononuclear cells filled with lipid material. Yeast bodies were not definitely identified.

*Kidneys:* Scattered throughout the sections were more nodules, the distribution of which was irregular. Many involved glomeruli and surrounding tissue, but they occurred in both the cortex and medulla. The areas were essentially granulomatous, some with a tubercle-like appearance having definite necrotic centers; others had relatively clear central spaces. The peripheral zone of all contained round cells, mononuclears, and a few polymorphonuclears. Yeast bodies were numerous in these nodules, and some tubules were actually filled with them.

*Adrenals:* Structure was essentially normal, except for a number of small foci of cellular infiltration containing essentially the same cells as seen in the kidney nodules. Few polymorphonuclears were present. In one or two foci there were definite suggestive yeast bodies.

*Lymph nodes, mediastinal:* Widespread obliteration of normal architecture had occurred with replacement by a large amount of scarring and many large granu-

lomatous areas having the appearance of Hodgkin's disease. Giant cells of the Sternberg type were numerous. In addition there were numerous foci many of which had necrotic centers, others involving lymphatic channels, especially around the periphery of the nodes. These foci and lymphatics contained abundant yeast bodies both free and intracellular. In one node there was a large caseous tubercle containing calcium, apparently representing healed tuberculosis.

*Abdominal, preaortic:* The predominant feature was widespread scarring, much of which had hyalinized. Certain granulomatous areas persisted with remaining lymphocytes, Sternberg cells, occasional plasma cells but with a rare eosinophile. A few necrotic areas were present, especially in the hyalinized portions. In these many yeast bodies were present as well as definite "shadows" of yeast bodies. A few could also be seen in the remaining granulomatous areas. Some were present in lymphatics and also in one or two rather large veins around the periphery of the node.

*Axillary:* Normal architecture was practically replaced by a definite granulomatous process similar to that described elsewhere; scattered foci containing yeast bodies were present.

*Inguinal:* Intense old scarring was seen with replacement of all normal architecture. A few granulomatous areas remained, very similar to those seen in Hodgkin's disease. Yeast bodies were again identified in many areas, even a few in the veins around the nodes.

*Peripancreatic nodes:* A process similar to that seen in the other nodes with no normal lymphoid tissue was present. A good deal of hemorrhage had occurred. Many yeast bodies were in evidence.

*Femoral bone marrow:* A very definite hyperplasia with areas of mild gelatinous changes was found.

*Vertebral marrow:* Occasional foci of rather concentrically placed mononuclear cells were evident, which suggested the type of reaction caused by torulae, although none could be definitely identified. The remainder of the section showed rather crowded cellular marrow elements.

A guinea pig which had been inoculated with material from the abdominal cavity at the time of the autopsy died five weeks later, with the lungs, liver, spleen, and lymph nodes showing torula infection, the organisms identified in the tissues.

*Comment.*—This case adds another to the recorded instances of generalized torulosis. There have been thirteen in the literature reviewed. Although there is pathologic evidence of involvement of the lymph nodes and certain viscera, unfortunately, permission was not granted for removal of the brain. There were, however, definite signs and symptoms referable to the central nervous system, and it seems highly probable that the infection was present. This clinical evidence, however, did not occur until late in the course of the illness.

The fact that a pathologic diagnosis of Hodgkin's disease was made from a lymph node removed three months before death, adds further to the interest. A search of the literature reveals only a few cases where such a diagnosis was made prior to the known occurrence of the torula infection. This interval has varied from three months in the present case to five years in the cases of Freeman and Weidman, and Owen. The association of torulosis with Hodgkin's disease is rare and in most of the reported cases, the previous diagnosis of Hodgkin's disease was based on a somewhat atypical appearance of the lymph nodes in ques-

tion. In two such instances, torulae were later found in the original biopsy. In our case, we believe that the original diagnosis of Hodgkin's is justifiable microscopically, but certain atypical features were present. On reviewing the slides we have been unable to definitely identify torulae in the nodes, but the appearance of the latter was such as to raise the suspicion that they may have been present, i.e., that the nodes represented a healing process with torulae as the inciting agent. From the study of the autopsy material it seems evident that some of the lesions, especially in the liver and in certain lymph nodes, were compatible with Hodgkin's disease. On the other hand, torulae were found in all the lymph nodes studied and in many lesions which were similar to those seen in Hodgkin's disease. The lesions containing torulae varied somewhat in appearance depending on their age, some being necrotic foci without much reaction, others exhibiting a rather pronounced cellular response. All were essentially granulomata.

From the evidence in this case and from others reported, one cannot escape the fact that torula infection produces granulomatous lesions which may closely simulate those seen in Hodgkin's disease. In the present study it seems certainly possible that the torula infection could have been the etiologic factor in producing the lesions encountered, lesions which were granulomatous and which might produce a picture both clinically and pathologically closely akin to Hodgkin's disease. We realize the difficulties in attempting to prove such a relationship and can only offer the evidence given here in discussing the question. This has been previously done, especially by Fitchett and Weidman.

As to the kidney lesions, they were apparently rather typical for that organ. Due to their location the organisms must have been excreted in the urine. This has been observed previously<sup>8</sup> and we again call attention to the possibility of identifying the yeast cells in the urine as a diagnostic aid.

CASE 3.—Mrs. C. I. (Hist. No. 146458), a white woman, aged 41 years, was admitted to the University of Virginia Hospital Feb. 13, 1939, with the complaint of pain and the occurrence of a mass in the right thigh.

The family, past, and marital histories were irrelevant.

She had first noticed a dull, aching pain on the inner aspect of the right thigh six months prior to admission. During the ensuing months the pain had been fairly constant, radiating down the medial side of the thigh into the calf fairly frequently, but never disabling. About six weeks prior to admission she had noticed the appearance of a nontender, firm mass about the size of an egg in the anteromedial aspect of the thigh. The mass had grown rapidly larger and extended around the thigh medially. No masses had been noticed anywhere else, nor any glandular enlargement. She had consulted her family physician, who had referred her to the hospital.

Physical examination revealed a firm, slightly tender, almost immovable mass of the soft tissues of the upper anterior and medial aspect of the right thigh, measuring 8 by 4 by 2 inches, with no skin or bony attachment. There was no redness nor increased heat, nor any enlarged glands in the groin. The remainder of the examination revealed no abnormalities. Her temperature was 99° F.

Laboratory study revealed no abnormalities except for some elevation of the leucocytes. Her hemoglobin was 84 per cent, the red blood cells 5,130,000, the white blood cells 11,200. Urine examination and Wassermann and Kahn reactions were negative. The blood calcium, phosphorus, and phosphatase were within the normal range.

As x-rays of the lungs and the hip and thigh regions were negative except for a hazy soft tissue shadow, the mass was aspirated and several plugs of tissue and much thick, glary, mucinous material withdrawn.

The initial report on the culture and smear from Dr. W. E. Bray's laboratory of clinical pathology was blastomyces, and from the department of pathology, blastomycosis of the soft tissues. Further cultures were taken and studied rather extensively by Dr. Briay and Dr. George M. Lawson of the department of bacteriology and public health with the conclusion reached by both that the organisms were not blastomyces but torulae. The diagnosis was based on the rapidity of the growth, the reproduction by budding, the failure to produce mycelia, and the morphologic and cultural appearance of the organism.

In spite of thymol administered systemically and by local injections, the mass continued to enlarge and extended posteriorly to the gluteal fold. The patient started running a low-grade fever, with temperature from 99 to 100° F. Amputation of the leg at the hip joint in an effort to eradicate the local lesion surgically was suggested Feb. 19, 1939, but due to the fact that there was no unanimity of opinion among the members of the surgical staff and that the patient's family had to be contacted, action was delayed until March 10, 1939.

On this date, under spinal anesthesia, disarticulation of the right leg at the hip joint was performed. During the procedure gelatinous exudate and diseased tissue were encountered, and the incision had to follow closely the pelvic bone in order to remove all diseased tissue. A drain was left in the wound, and the patient was given potassium iodide therapy systemically.

Cultures from the exudate encountered at the time of operation again revealed torulae. Pathologic examination of the thigh region revealed grossly a spacious irregular "abscess" cavity with the walls of the cavity ill-defined and dissecting between the muscle and fascial planes, at points seeming to destroy these tissues. The cavity had been cut into at its upper end and was filled with a viscid grayish-white, glistening, mucinous material, which was odorless. Microscopic examination of stained sections revealed almost complete loss of tissue in the central portions of the mass, with the tissue replaced by torulae, phagocytes, many of which contained torulae, polymorphonuclears and lymphocytes with mucinous intercellular material. Sections of the wall revealed a poorly developed type of granulation tissue reaction in which lymphocytes greatly predominated. The sections also showed foreign body giant cells and phagocytes containing debris and torulae. The surrounding muscles and soft tissues showed some round cell infiltration.

The patient was discharged on the twenty-second postoperative day, afebrile and with the stump almost healed. On a return visit six weeks later the stump had healed entirely, and there were no other manifestations of the disease.

She returned to the hospital Oct. 24, 1939 with the complaint of slight bloody drainage from a small area which had appeared in the center of the amputation scar ten days previously. Otherwise she had enjoyed good health. Examination revealed a sinus tract 2 mm. in diameter in the central portion of the scar which could be probed to a depth of 1 cm. There was no surrounding induration or tenderness. A smear from the sinus tract revealed bodies which appeared to be torulae. A culture, however, was negative for torula. X-rays of the hip and chest were negative. Under spinal anesthesia the tract was thoroughly cauterized and then completely excised. Examination of this tissue revealed a chronic inflammatory change in the tissues and a few bodies which may have been torulae, but these could not be definitely identified because of the effect of the cautery. She was discharged with the area healing satisfactorily.



She has been seen several times since discharge from the hospital. She has remained in good health and the stump healed with no sign of recurrence of the disease. June 25, 1913, she stated, in reply to a letter of inquiry, that she had had no further trouble.

*Comment.*—Case 3 represents the rare localized form of torulosis, like the soft tissue infections reported by Brewer and Wood, and McGehee and Michelson. The patient has apparently been cured following radical surgery. Internal administration of potassium iodide postoperatively was employed.

CASE 4.—Miss K. N. (Hist. No. 185353), a white woman, aged 24 years, was admitted to the University of Virginia Hospital, Dec. 3, 1942, with the complaint of headache, nausea, and vomiting.

The family and past histories were not significant.

She had developed a severe throbbing headache five days before admission to the hospital, which had not been relieved by the usual analgesics. Two days before admission nausea and vomiting had started.

Physical examination revealed the following abnormalities: blurring of the nasal side of both optic discs; slight stiffness of the neck on admission which in a period of twelve hours increased greatly; and a temperature of 101.4° F.

Laboratory studies were as follows: hemoglobin 68 per cent (Dare), red cell count 3,480,000, white cell count 11,000, with a smear showing a normal distribution of cells. Urine and stool specimens were essentially normal. The blood urea was 45 mg. per 100 c.c. A spinal puncture performed shortly after admission revealed a pressure of 200 mm. of water. The fluid was clear, there was a moderate increase in globulin, and a count of 80 cells, with a predominance of lymphocytes. A smear was negative, but the culture later showed torula.

Before the report of the positive culture, a diagnosis of benign lymphocytic choriomeningitis was made. Another spinal puncture revealed 390 cells with a predominance of polymorphonuclears. She was then given sulfadiazine for one day and sulfapyridine until four days before death. Potassium iodide was given by mouth, and acriflavine intrathecally. Torula organisms were recovered from the blood stream.

During the course of the illness she continued to complain of headache, steadily lost weight, and remained semicomatose or comatose most of the time. Repeated spinal punctures were done, and the spinal fluid pressure steadily rose to over 700 mm. of water. December 22, through bilateral postparietal burr openings, a ventriculogram was made in order to rule out internal hydrocephalus. The films revealed normal ventricles. On December 25, she lapsed into deep coma and respirations stopped rather abruptly. Permission for autopsy was not granted.

*Comment.\**—This was primarily a case of central nervous system torulosis, the organism being recovered on smear and culture of the spinal fluid at many different times. There was one positive blood culture, although no other foci of infection were evident during the course of the illness.

CASE 5.—This is a follow-up report on Magruder's Case 3. To review briefly his protocol; she was a 22-year-old colored female, admitted to the University of Virginia Hospital on April 23, 1937, complaining of headache of three months duration, accompanied by pain in the neck of five weeks duration. She also had at various times, earache, tinnitus, photophobia, diminished visual acuity, anorexia, and vomiting. She was admitted in an irrational state and examination revealed

\*This case will be reported in more detail by a member of the Department of Medicine.

definite choking of the optic discs, a large amount of exudate and several recent hemorrhages, slight stiffness of the neck, slight deviation of the tongue to the left, left biceps reflex greater than the right, sluggish patella reflexes, and absent Achilles tendon reflexes.

Laboratory work revealed no abnormalities except in the spinal fluid which showed yeastlike organisms which were cultured and identified as *torula*. She continued to have headache and transient spells of nausea and pain in the neck. Jan. 28, 1938, a culture of the spinal fluid revealed *torula*.

Since the last follow-up reported by Magruder, she returned to the outpatient clinic at various times complaining of backache, headache, nausea, and vomiting. April 29, 1940, these symptoms were accentuated, and examination revealed the right disc hazy and irregular in outline, with no other neurologic abnormalities noted. A lumbar puncture was performed with the initial pressure 160 mm. of water. The spinal fluid dynamics were normal, and the fluid was clear and colorless. The cell count was 142, with a predominance of lymphocytes. Colloidal gold curve was 5555553200. Spinal fluid protein was 225 mg., chlorides 710 mg., and sugar 21 mg. per 100 c.c. respectively. *Torula* organisms were again cultured from the spinal fluid. She died at home, May 6, 1940, having lived three years, four months after the onset of symptoms.

*Comment.*—Case 5 is one of *torula* infection of the central nervous system of three and one-third years, one of the longest cases on record. Wile reported a patient who may have had the disease seven years before death; Levin's patient died after five and one-half years, and patient in the case of Cudmore and Lisa<sup>7</sup> lived four years. Levin found the duration of the disease variable, with the majority of instances having one to six months of illness. In the present case *torulae* were repeatedly found on culture and smear of the spinal fluid. The patient received some alleviation of symptoms and returned to work temporarily following spinal drainage.

#### SUMMARY

A brief review of *torula* as it affects the human body has been given. Invasion of the central nervous system is most common, with an associated generalized form sometimes seen. Localized infections are rather infrequently encountered. The relationship of Hodgkin's disease and torulosis in the reported cases has been noted.

We have recorded four additional cases of torulosis. In the first, a case of central nervous system torulosis, the diagnosis was made at autopsy. In the second, a case of generalized torulosis, there were some central nervous system signs, in which a diagnosis of Hodgkin's disease was made previously from biopsy material. In the third, a case of localized torulosis of the thigh, an apparent cure was effected by radical surgery and the internal administration of potassium iodide. In the fourth, a case of central nervous system torulosis, the diagnosis was made by smear and culture of spinal fluid. A follow-up report of Magruder's third patient who died of cerebrospinal torulosis after three and one-third years was also given.

We wish to express appreciation to Dr. W. Ansell Derrick, Department of Pathology, for valuable aid rendered in microscopic study of the tissues.

## REFERENCES

1. Alvarez, R. S.: A Red Torula as the Cause of a Tongue Abnormality, *J. A. M. A.* 87: 1138, 1926.
2. Berghausen, O.: Torula Infection in Man, *Ann. Int. Med.* 1: 235, 1927.
3. Binford, C. H.: Torulosis of the Central Nervous System, *Am. J. Path.* 11: 242, 1941.
4. Brewer, G. E., and Wood, F. C.: Blastomycosis of the Spine, *Ann. Surg.* 48: 889, 1908.
5. Cabot, R. C.: Torula Meningitis: Lymphoblastoma, Hodgkin's Type (Cabot Case 20241), *New England J. Med.* 210: 1291, 1934.
6. Cudmore, J. H., and Lisa, J. R.: Torula Meningo-encephalitis: A Case Report, *Ann. Int. Med.* 11: 1747, 1938.
7. Dandy, W. E., and Kindell, H.: Case Reported by Freeman.<sup>10</sup>
8. Fitchett, M. S., and Weidman, F. D.: Generalized Torulosis Associated With Hodgkin's Disease, *Arch. Path.* 18: 225, 1934.
9. Freeman, W.: Torula Meningo-encephalitis: Comparative Pathology in Nineteen Cases, *Tr. Am. Neurol. A.* 56: 203, 1930.
10. Idem: Torula Infection of the Central Nervous System, *J. f. Psychol. u. Neurol.* 43: 236, 1931.
11. Freeman, W., and Weidman, F. D.: Cystic Blastomycosis of the Cerebral Gray Matter, Caused by Torula Histolytica Stoddard and Cutler, *Arch. Neurol. & Psychiat.* 9: 589, 1923.
12. Frothingham, L.: A Tumor-Like Lesion in the Lung of a Horse Caused by a Blastomycetes (Torula), *J. Med. Research* 9: 31, 1902.
13. Gill, W. D.: Torula Mycosis in Man, With Special Reference to Involvement of Upper Respiratory Tract, *Tr. Am. Laryng., Rhin. & Otol. Soc.* 40: 247, 1934.
14. Hardaway, R. M., and Crawford, P. M.: Pulmonary Torulosis, Report of a Case, *Ann. Int. Med.* 9: 334, 1935.
15. Jones, E. L.: Torula Infection of the Nasopharynx, *South. M. J.* 20: 120, 1927.
16. Levin, E. A.: Torula Infection of the Central Nervous System, *Arch. Int. Med.* 59: 667, 1937.
17. Magruder, R. G.: A Report of Three Cases of Torula Infection of the Central Nervous System, *J. Lab. & Clin. Med.* 24: 495, 1939.
18. McGehee, J. L., and Michelson, I. D.: Torula Infection in Man, Report of a Case, *Surg., Gynec. & Obst.* 42: 803, 1926.
19. Mook, H. W., and Moore, M.: Cutaneous Torulosis, *Arch. Dermat. & Syph.* 33: 951, 1936.
20. Owen, M.: Generalized Cryptococcosis Simulating Hodgkin's Disease, *Texas State J. Med.* 35: 767, 1940.
21. Rappaport, B. Z., and Kaplan, B.: Generalized Torula Mycosis, *Arch. Path.* 1: 720, 1926.
22. Reeves, D. L., Butt, E. M., and Hammack, R. W.: Torula Infection of the Lungs and Central Nervous System, *Arch. Int. Med.* 68: 57, 1941.
23. Rusk, G. Y., and Farnell, F. J.: Systemic Oidiodermatitis, *Univ. California Publ., Path.* 2: 47, 1912.
24. Sheppe, W. M.: Torula Infection in Man, *Am. J. M. Sc.* 167: 91, 1924.
25. Smith, F. B., and Crawford, J. S.: Fatal Granulomatosis of the Central Nervous System Due to a Yeast Torula, *J. Path. & Bact.* 33: 291, 1930.
26. Stoddard, J. L., and Cutler, E. C.: Torula Infection in Man, Monograph 6, Rockefeller Inst. Med. Research, 1916.
27. Urback, E., and Zack, F.: Generalisierende Torulose, *Arch. f. Dermat. u. Syph.* 162: 401, 1930.
28. Verse, M.: Ueber einen Fall von Generalisierender Blastomykose beim Menschen, *Verhandl. d. deutsch. path. Gesellsch.* 17: 275, 1914.
29. Von Hansemann: Ueber eine bisher nicht Beobachtete Gehirnerkrankung durch Hefen, *Verhandl. d. deutsch. path. Gesellsch.* 9: 21, 1905.
30. Warvi, W. N., and Rawson, R. W.: Torula Meningitis, *Arch. Int. Med.* 69: 90, 1942.
31. Watts, J. W.: Torula Infection. A Review and Report of Two Cases, *Am. J. Path.* 8: 167, 1932.
32. Weidman, F. D.: Cutaneous Torulosis, *South. M. J.* 26: 851, 1933.
33. Weidman, F. D., and Ratcliffe, H. L.: Extensive Generalized Torulosis in a Cheetah, *Arch. Path.* 18: 362, 1934.
34. Wile, U. J.: Cutaneous Torulosis, *Arch. Dermat. & Syph.* 31: 58, 1935.
35. Zenker: Encephalitis mit Pilzenwicklung im Gehirn, 1861, *Jahresv. d. Gesellsch. f. Natur. u. Heilk. in Dresden*, page 51. (Quoted by Freeman.<sup>10</sup>)

# A "LUCITE" GASTROSTOMY TUBE FOR POUCH DOGS AND POSSIBILITIES FOR APPLICATIONS IN MAN

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NO SINGLE procedure has contributed as much to our knowledge of the physiology of gastric secretion, as has the study of gastric juice obtained from the isolated gastric pouch in dogs. Since the isolation of gastric pouches by Heidenhain and Pavlov, many types of cannulas have been devised of various materials for the collection of the pouch juice. Few have been completely satisfactory. Most failures have been due to (1) the use of a material giving rise to tissue irritation, (2) removal of the cannula by the experimental animal, and (3) seepage about the gastrostomy tube. Dragstedt and associates<sup>2, 3</sup> has employed a gold plated cannula with satisfaction.

In this laboratory different types of metals and alloys have been used with little success.<sup>7</sup> During the past few years, a No. 30 French rubber mushroom catheter, anchored from the inside, to the lowermost costal cartilage has given the best results. When this method was used, a number of dogs pulled out the tubes. A high mortality resulted from attempted reinsertion of the tube, and in some dogs a second operation was necessary. Thomas<sup>9</sup> reported in his experience, over a period of eight years, that approximately one-half of their animals were lost within the first few weeks after operation because of cannulas coming out, being pulled out, or destroyed by the animal. Our own experience suggested a search for a more satisfactory substitute.

"Lucite" was used in medicine by McCrea,<sup>8</sup> in 1938, when he reported two cases in which "lucite testicles" were implanted into the scrotal sac. Examination one year later revealed no outward evidence of tissue irritation. Dennis<sup>1</sup> employs lucite drains in the surgical treatment of pyogenic osteomyelitis. He observed that subcutaneous implantation of lucite in animals revealed a moderate tissue reaction. In 1943, Harmon<sup>6</sup> fashioned plastic cups of lucite and "plexiglass" for arthroplasty of the hip in cases of osteoarthritis with satisfactory results.

Lucite,<sup>4</sup> a plastic resin, is a polymeric alpha-methyl-methacrylate—a compound ester of acrylic type. It is unaffected by aqueous solutions of mineral salts of dilute alkalies. Lucite is resistant to hydrochloric acid and 50 per cent sulfuric acid at room temperature. It is insoluble in straight chain hydrocarbons, fats, oils, and waxes. Lucite is readily

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dissolved by lower ketone and ester solvents and mixtures of aromatic hydrocarbons with small amounts of alcohol

The physical properties of lucite are:

1. Specific gravity is 1.18 to 1.20.
2. The water absorption of lucite is negligible.
3. Tensile strength, 9,000 to 12,000 lb. per square inch (approximately the same tensile strength of cast zinc; two to three times that of cast or drawn tin; three to four times that of cast or drawn lead<sup>2</sup>).
4. Transverse (flexural) strength 12,000 to 14,000 lb per square inch.
5. The impact resistance and hardness are sufficient to withstand body strains.

Cast lucite in the form of sheets, rods, and tubes will soften at temperatures from 190 to 240° F. It is colorless and has a high light transmission. It can be cut, molded, easily machined, drilled, and polished. Pieces can be cemented together by active solvents or lucite cement. Such joints are mechanically as strong as the material itself.

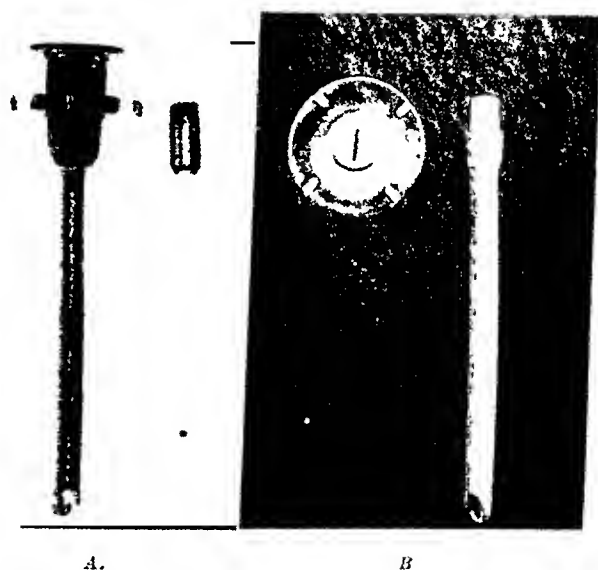


Fig. 1.—A, Photograph of the "lucite" gastrostomy tube, with the tubular middle piece inserted and the rubber tubing attached. B, End-on photograph of the lucite gastrostomy tube with the solid middle piece inserted.

In September of 1942, we first used a lucite gastrostomy tube in a pouch dog. Modifications of the original design were made until a satisfactory mechanism was found. (See Figs. 1 and 2.)

*Operative Procedure.*—The dog is prepared for surgery in the routine manner. Intratracheal ether or intravenous sodium pentobarbital (15 mg. per pound of body weight) is used. A left mid-rectus incision is made, and the stomach is identified. A gastric pouch is fashioned from the greater curvature of the stomach. Approximately three quarters of the mucosa of the isolated gastric pouch is then inverted by a running Connell suture (catgut No. 000). Following this, conduit A (see Fig. 2)

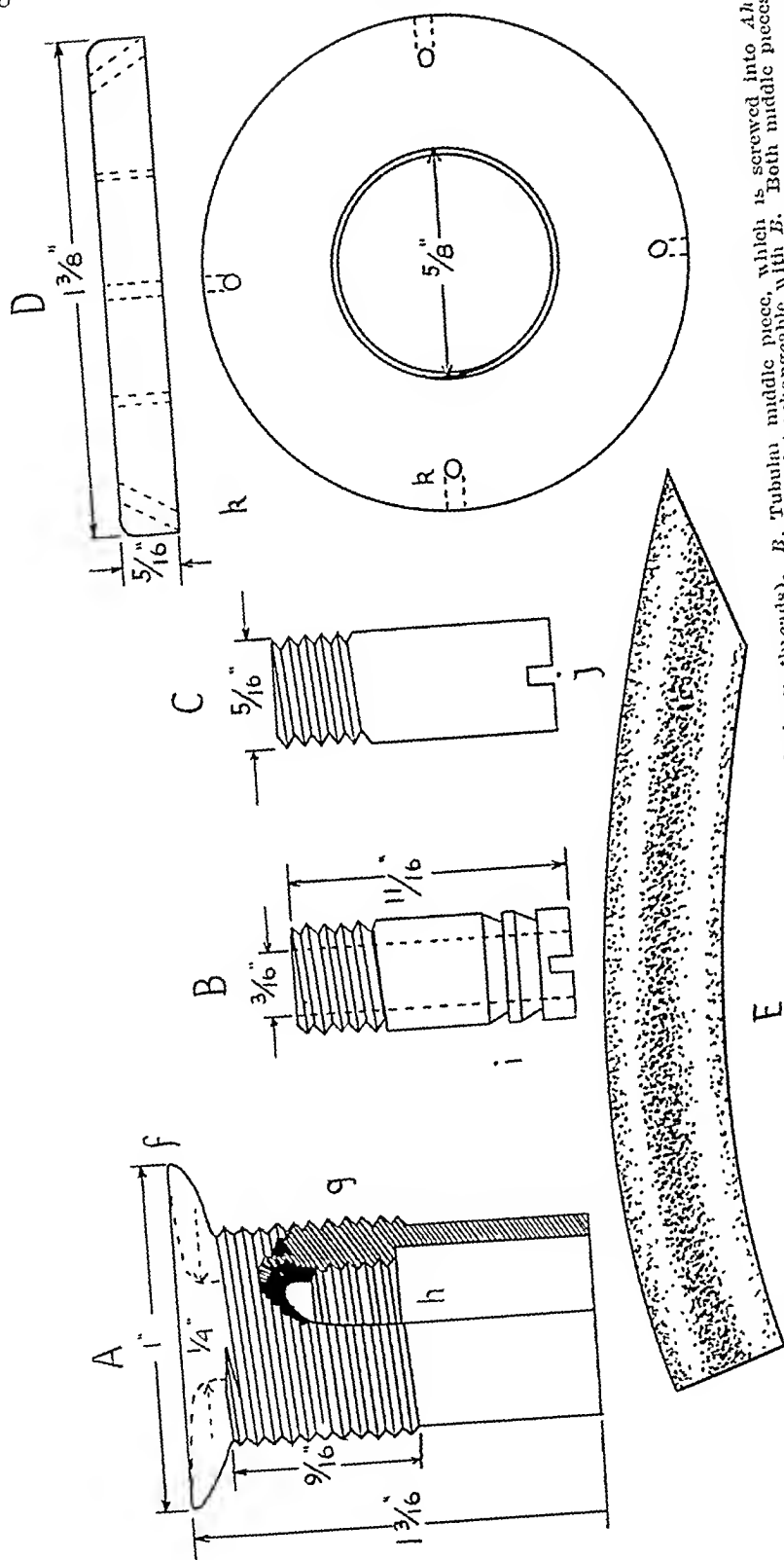


FIG. 2.—A, Single piece conduit (*f*, inner shoulder; *g*, outer threads; *h*, inner threads). B, Tubular middle piece, which is screwed into *A*, *h*, after rubber tubing. E, has been shipped over corrugated surface, *h*. C, solid middle piece which is interchangeable with B. Both middle pieces have screw slots, *j*. D, Outer shoulder which is screwed upon *A*, *g*. *k*, Angulated holes perforating D.

\*Solid middle piece, C, is of little value for use in pouch dogs except for the intermittent collection of pouch juice. For use in man this part has other implications, which will be discussed briefly.

is inserted into the pouch. A stab wound is made through an area of the pouch wall away from the line of closure of the pouch. This procedure permits conduit *A* to be pulled through so that the inner shoulder *f* rests against the gastric mucosa. The Connell suture of the mucosa is now completed. A Murphy inverting stitch or purse-string suture is taken in the pouch wall about the conduit and tied. Rubber tubing, *E*, is inserted over *Bi*, and *B* is screwed into *Ah* (see Fig. 2). The serosa-to-serosa closure of the pouch is now completed with Halsted interrupted mattress sutures of cotton. The residual stomach is closed in a similar fashion. A puncture hole is then made through the omentum, and the gastrostomy tube is pulled through. This maneuver allows omentum to surround the isolated pouch. The abdominal wall, including the anterior rectus sheath, is now closed about the gastrostomy tube. Shoulder *D* is then screwed onto *Ag* until the serosal surface of the pouch is pulled snugly against the anterior abdominal wall (see Fig. 3). Shoulder, *D*,

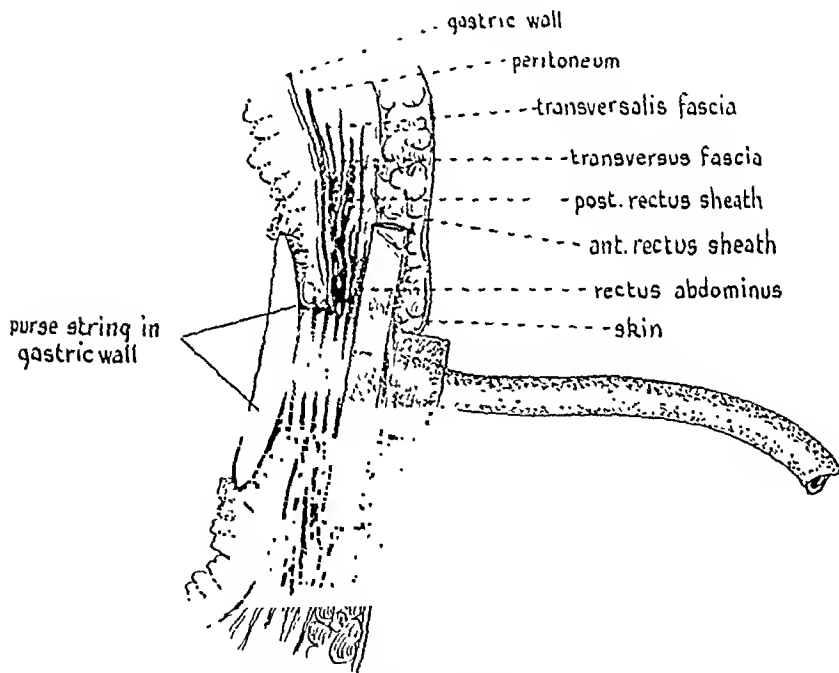


Fig. 3.—A sagittal section of the abdominal wall with the lucite gastrostomy tube in situ. (Gray's Human Anatomy.)

is sutured to the anterior rectus sheath through the angulated holes, *k*. The subcutaneous tissue and skin are closed over shoulder, *D*. Sulfanilamide is used intraperitoneally and in the abdominal wall. An ordinary spool of cotton thread, No. 40, is used exclusively in the abdominal wall closure. At the conclusion of the procedure approximately one-eighth inch of conduit *A* extends above the skin. Postoperative edema causes conduit *A* to become immediately subcutaneous after two or three days.

The sterilization of the unassembled gastrostomy tube is accomplished by immersion in 1:2500 dilution of metaphen for one hour. No gross infection was noted in any case. McCrea<sup>8</sup> used formaldehyde for sterilization. A 5 per cent concentration of formaldehyde U.S.P. (neutral) has no effect on lucite. Harmon<sup>6</sup> used mercuric oxycyanide (0.2 per cent solution) and mercuric chloride (0.1 per cent solution) for sterilization.

We have performed eight such operations. The final gastrostomy tube was used in the last three dogs. These three dogs died, soon after operation, of distemper which was epidemic in the laboratory at the time. No death occurred incident to the use of the lucite gastrostomy tube. The gastrostomies were functioning well before death.

Dogs examined at autopsy or operation revealed the tissue to have hugged the lucite gastrostomy tube intimately. This tissue immediately surrounding the tube grossly appeared to be fibrous in character. The gastrostomy was watertight. The inner shoulder, *f*, of conduit *A* was slightly blackened. This was cleaned with ease. The threads were intact and not distorted.

This lucite gastrostomy tube has the following advantages:

1. It cannot be removed by the dog.
2. If the rubber tubing is pulled off it can be replaced easily without risk to the animal. This can be done by unscrewing the middle piece, *B*, and using the screw slot, *j*, while holding the end of conduit *A* with a hemostat. This precaution should be taken because theoretically conduit *A* would tend to unscrew off shoulder *D*.
3. It is watertight.
4. It has the advantages of lucite.

#### POSSIBILITIES FOR APPLICATIONS IN MAN

This gastrostomy tube could be used in patients in whom a permanent gastrostomy is contemplated. The middle piece, *B*, with rubber tubing attached would be used for feeding while solid plug, *C*, would be used between feedings to prevent any leakage of gastric contents onto the skin.

For use in man, the following modifications are recommended: (1) Increased diameter of the aperture of conduit *A*; (2) increased overall length of this conduit with attendant changes in the placement of the threads, length of middle piece *B*, etc.; (3) a wider inner shoulder *f*; (4) end of conduit *A* squared so that it may be easily grasped; (5) winged middle pieces *B* and *C* so that they may be interchanged without the aid of a mechanical device.

We have also used this lucite tube for cystostomy in a dog to determine its applicability for permanent cystostomy in man. The cystostomy tube in this animal was closed at all times by the insertion of a solid middle piece, *C*, at the time of operation. After 141 days this dog was



sacrificed. A stone 1 by  $\frac{3}{4}$  inch was found in the bladder. This calculus was completely detached from the lucite tube.\*

Subsequently, a lucite screw was implanted into the urinary bladder of another dog. One hundred forty-one days later, the screw was recovered from the bladder. It was clean, the threads were intact, and no encrustations nor calculi were present. Perhaps the insertion of the cystostomy tube in the first animal distorted the bladder sufficiently to allow urinary stasis with resultant stone formation.

Recently, we repaired an artificially made abdominal wall defect in a dog with a lucite plate. Although the lucite plate fitted well, satisfactory fixation to the tissues was technically difficult. A few days later it was necessary to reoperate upon this dog and attempt fixation again. Infection occurred and the plate was removed. If a satisfactory method of fixation can be devised, the use of a lucite plate for the repair of hernial defects may prove feasible.

#### CONCLUSIONS

1. A lucite gastrostomy tube for pouch dogs has been described with a note concerning its possible applications in man.

2. Lucite has physical, chemical, and workable properties satisfactory for use in tissues.

3. We have been encouraged with the behavior of lucite and feel that in tissue defects which cannot be reconstructed satisfactorily by surgery, nonreactive plastic materials should be investigated to ascertain their value.

#### REFERENCES

1. Dennis, C.: Prolonged Dependent Drainage With "Lucite" Drains in the Treatment of Chronic Osteomyelitis, *SURGERY* 13: 900, 1943.
2. Dragstedt, L. R., and Ellis, J. C.: The Fatal Effect of Total Loss of Gastric Juice, *Am. J. Physiol.* 93: 407, 1930.
3. Dragstedt, L. R., Montgomery, M. L., and Ellis, J. C.: A New Type of Pancreatic Fistula, *Proc. Soc. Exper. Biol. & Med.* 28: 109, 1930.
4. Dupont De Nemours and Company: Manual on "Lucite."
5. Handbook of Chemistry and Physics, 25th edition, 1941-1942, published by Cleveland Rubber Company.
6. Harmon, P. H.: Arthroplasty of the Hip for Osteoarthritis Utilizing Foreign Body Cups of Plastic, *Surg., Gynec. & Obst.* 76: 343, 1943.
7. Hay, L.: Unpublished data.
8. McCrea, L. F.: Lucite: A New Synthetic Material Suitable for Testicular Prosthesis, *Urol. & Cutan. Rev.* 42: 723, 1938.
9. Thomas, J. E.: An Improved Cannula for Gastric and Intestinal Fistulas, *Proc. Soc. Exper. Biol. & Med.* 46: 260, 1941.

\*Also, in this the bladder. It formed a nucleus.

\*\* cotton sutures were used in the closure of the sutures sloughed into the bladder and

# Editorial

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## Use of Nonabsorbable Sulfasuxidine in Extensive Burns

THE search for an adequate treatment of the extensive burn case has rivaled that of Diogenes and only during the last two decades has it been done in the manner of other medical researches. There is no doubt that Davidson, in 1925, when he suggested the use of tannic acid, gave a really noteworthy stimulus to this investigation.

The better understanding of shock in burn cases and the use of blood plasma have presented the surgeon with the problem of completing successfully the treatment of the extensive third degree burn case. Many of these patients have a minimum of skin for donor sites for skin grafting and require multiple grafting procedures over a considerable length of time. We are then confronted with the rather difficult problem of keeping the burned area clean enough for skin transplantation without resorting, unless absolutely necessary, to the temporary use of homo-grafts.

The use of any type of closed treatment with eschar formation must necessarily be at least a temporary postponement of the eventually necessary replacement of the destroyed skin. A better plan is a semiclosed method which can be opened at the earliest time that grafting can be done or when any complications arise. With this in mind, many treatments have been devised since the advent of sulfonamide therapy, all using sulfanilamide, sulfathiazole, or sulfadiazine as the bacteriostatic agent. Their value has been described by many authors. However, the dangers of using these drugs in the large quantities necessary in extensive burns are well known. The kidneys must excrete up to 29 per cent of the dose of the sulfonamides, according to Matthews, which places a rather severe strain on the renal function, especially one that is already probably taxed to the limit by the burn itself.

With these considerations in mind, during the past year, the non-absorbable sulfonamide, sulfasuxidine, has been used in a series of extensive burns as the bacteriostatic agent and has been found to facilitate earlier multiple grafting operations. The cases have had total third degree burns of from 20 to 45 per cent of the body surface according to Berkow's tables. Up to 25 Gm. of sulfasuxidine have been dusted on the granulating areas and then a pressure dressing of boric acid ointment applied.

Under this regime the patients have never shown any toxic effects and repeated blood concentrations have always been zero. Those who were having rather high temperatures have had noteworthy reduction in fever. The method has been decidedly easier on the patients than some treatments as the dressings are not changed for periods of from four to eight days. The granulation tissue has become and remained clean enough for multiple transplantation of large split grafts, without the loss of any grafts.

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# Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M.D.

## WOUND DISRUPTION AND CATGUT ALLERGY—AN EXPERIMENTAL AND CLINICAL STUDY

WITH A REVIEW OF THE LITERATURE

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THE problem of wound disruption in abdominal surgery is entirely one of wound healing and has been the subject of lengthy investigation. The first report in the American literature was that of Brehauer,<sup>1</sup> who in 1899 reported 3 cases of disruption. The first comprehensive report was published by Madelung,<sup>2</sup> in 1905, when he reviewed 157 cases including 13 which he and his associates had observed. Ries<sup>3</sup> gave an account of 6 cases, in 1909. In 1925, Holterman<sup>4</sup> reviewed 15 cases which represented an incidence of 2 per cent in a series of operations performed. In the same year, Shipley<sup>5</sup> described a method of secondary closure of disrupted wounds by the use of silver wire which could be tightened up over buttons. In 1931, Sokolov<sup>6</sup> published data on 725 cases of wound disruption he had compiled by sending out questionnaires to many European surgeons.

The symposium on wound disruptions conducted by the New York Surgical Society, in 1933, was the most important event in drawing to the attention of the American surgical profession the prevalence of this postoperative calamity, for many surgeons had accepted dehiscence as an unavoidable disaster or act of God, which of necessity must occur in a small percentage of cases.

Before we assume that the healing powers and the stimuli to heal are defective or absent, we must make certain that delayed healing is not due to impediments which we have put in the way. Nature works methodically: the removal of debris, blood clots, dead tissue, and bacteria must precede actual repair. To a large degree, both the systemic and the local factors which may affect repair are under the surgeon's control.

### FACTORS INFLUENCING WOUND HEALING

The gross and microscopic changes coincident with wound repair are well known as are also many of the factors which influence them. The

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actual reparative stimuli, which appear to be protein in nature, are derived from leucocytes and other tissue-wandering cells and connective tissue.<sup>7</sup> These have been the subject of many studies. As to the actual nature of the healing process, however, how and why these growth-promoting substances act, we know very little, except to say that healing appears to be a natural property of living organisms, which under certain optimal conditions proceeds at a definite and measurable pace.

The factors which have to do with normal healing may be divided into those which act directly at the site of the injury, the local factors, and those which have an effect of a more general nature and act systemically.

#### GENERAL FACTORS

*Malignant Disease.*—The effect of malignant disease in retarding wound healing is a common observation. Malignancy is undoubtedly an important factor in the etiology of disruption as evidenced by its frequency of 25 per cent in the large group of cases studied by Jenkins.<sup>8</sup> To what extent anemia, old age, and poor nutritional state contribute to this observation is difficult to evaluate accurately. In the absence of malignancy the latter factors are also observed to influence the rate of healing of a wound.

*Hypoproteinemia.*—The effect of protein on wound healing deserves special reference since it has been exhaustively studied and very definite clinical evidence supports critical experimental work. The effect of protein on wound healing was suggested by experiments of Clark<sup>9</sup> and Harvey and co-workers,<sup>11</sup> and recently by Thompson, Ravdin and co-workers.<sup>10</sup> Carrel showed that the stimulus for wound healing was a protein, probably an embryonic type of protein, not present in all tissues but apparently occurring in white blood cells, tissue wandering cells, and connective tissue. Clark<sup>9</sup> found delay in healing in animals fed on low protein diets. Harvey and Howes<sup>11</sup> showed with experiments on guinea pigs that with high protein diets wound healing progressed about the same as with low protein diets. The latent period was the same; however, once fibroblastic proliferation started it proceeded more rapidly in animals on a high protein diet. Thompson, Ravdin, and co-workers have demonstrated, both with experiments and clinical observations on blood proteins in wound healing, that when hypoproteinemia exists, wound healing is retarded or may even cease and that when the protein is brought up to normal by the use of lyophile serum, normal healing takes place.

Howes, Sooy, and Harvey<sup>12</sup> have demonstrated experimentally that there is a quiescent phase, or "lag period," in the healing of a wound, during which time its tensile strength per se is zero. This period usually extends from four to six days. Clark<sup>9</sup> found that this period was susceptible to dietary control and could be reduced by a high protein

diet. But Harvey and Howes<sup>11</sup> contradict that statement and maintain that a high protein diet, while responsible for an acceleration in the rate at which the wound heals, does not alter the duration of the initial lag period. The first five or six days of wound repair are the critical days. During this time, the lag period or exudative phase of wound repair, the stage is being set for the abrupt onset of fibroplasia. Necrotic tissue is being liquefied and removed, bacterial contaminants are being dealt with, and an increasing local resistance to bacterial invaders is developing. The tensile strength of the wound during this period depends almost entirely upon the sutures and the relaxation obtained by rest and splinting. Rest and avoidance of unnecessary manipulation are therefore particularly essential to proper healing during the exudative phase. It is at this time, as DuMourtier<sup>12</sup> has shown, that the sutured wound is more susceptible to infection. Following the lag period the tensile strength of the wound rapidly increases until the maximum level is reached in from ten to fourteen days. Probably the most significant aspect in the healing of any wound, as far as the clinical application of the physiologic mechanism is concerned, is the presence of a lag period with its concomitant negligible tensile strength. It is obvious that during this period the wound requires support to maintain coaptation of its margins.

Koster and Kasman,<sup>20</sup> in a study of serum proteins in a series of 40 wound disruptions and 40 well-healed controls, concluded that "hypoproteinemia by itself is neither a necessary nor a sufficient cause for wound disruption, but a poor nutritional state of which hypoproteinemia is a manifestation may favor wound disruption."

**Vitamin C.**—Vitamin C is intimately related to the production of fibrous tissue, and hence becomes an exceedingly important factor in the repair of wounds. Vitamin C deficiency as a cause for disturbances of wound healing was suggested by Sokolov<sup>6</sup> in a study of postoperative wound disruption, when he found that wound disruption occurred with greater frequency during the late winter and early spring months and expressed the idea that this was due to vitamin deficiency since the patients from whom the statistics were drawn were of the northern European races whose vitamin C intake was much curtailed during winter. Subsequent experimental studies and clinical investigations by Lamman and Ingalls<sup>11</sup> have definitely borne out Sokolov's original suggestion, for they found that in guinea pigs placed on diets low in vitamin C incisions healed poorly, more slowly, and with the development of less tensile strength than in the normal controls. In addition, they observed the case of an infant with congenital atresia of the intestine in whom wound disruption occurred following operation. Tissue studies after death showed typical changes of scurvy. Taffel and Harvey<sup>15</sup> conducted similar experiments and found that in scorbutic guinea pigs there was definite delay in the development of normal tensile strength in healing wounds.

It has been pointed out that normal repair of wounds takes place through a process of fibroblastic proliferation of connective tissue and the formation of collagen. While it is true that severe malnutrition is in itself a deterrent to normal wound healing, it seems that vitamin C is a particularly important factor in this connection. Metheny<sup>16</sup> gives several case reports of patients in whom delayed wound healing was brought about by deficiency of vitamin C, and he therefore advocates that undernourished patients be tested for vitamin C content of the blood, and where this is less than 1 mg. per cent, the patient be given a sufficient amount of ascorbic acid to bring the blood vitamin C to this level. Lauber and Rosenfeld<sup>17</sup> also have advanced evidence to prove that vitamin C deficiency results in serious interference with tissue regeneration and wound healing. The presence of disease, especially of the gastrointestinal tract, often causes radical changes in the dietary habits and almost invariably results in improper nutrition. Thus, the patient who has suffered from peptic ulcer, malignancy of the gastrointestinal tract, or other types of cachexias and food deficiencies is the one most frequently subject to wound disruption. Such patients may often show low vitamin C content in the blood even though there are no actual signs or symptoms of scurvy.

*Other General Factors.*—There are a certain number of general factors which have a direct or indirect effect upon wound healing. Carrel<sup>7</sup> has shown that the healing of wounds occurs at a rate inversely proportional to age, and other investigators have confirmed this observation. We are all familiar with the delayed healing which may occur in the aged, but we all know also that healing does occur in the aged as well as in the young, and that often the disease rather than age alone is the more important factor. Mason<sup>18</sup> has stated that even in acute starvation healing proceeds as usual unless the starvation actually threatens life itself. The urge to heal is almost equal to the urge to live, and nature will surmount all obstacles to close a wound. Certain diseases such as diabetes and nephritis retard healing, through what mechanism we cannot be certain, although we must think of hypoproteinemia and anoxemia. Dehydration of even moderate degree has a marked depressant effect upon repair in general and experimentally. Anderson<sup>19</sup> has shown it to lead to striking weakness in healing wounds. Distant infection is said to have a deleterious effect upon wound healing and this statement is supported by Carrel's experimental work.<sup>7</sup>

#### LOCAL FACTORS

*Débridement.*—It is a universally accepted surgical principle that foreign matter including nonviable tissue must be removed from a wound if normal healing is to be expected, because removal of such material must precede the fibroplastic reaction essential to tissue union. Removal by leucocytes is a laborious and slow process, so the less such material is left in the wound by the surgeon, the less will be the delay

in healing. The second reason for débridement is even more important. Foreign material acts as a nidus for infection, as will be emphasized in the subsequent discussion of nonabsorbable suture material, and permits bacteria to adjust to their environment and begin to grow before white cells gain access to them. Pickrell<sup>29</sup> has shown that if bacteria are introduced into the body during deep surgical anesthesia, they will grow uninhibited by the defenses of the body during the entire period of unconsciousness, and this, regardless of the amount of immunity possessed by the body against the bacteria. If bacteria are able to grow unrestrictedly during several hours, they may easily become so numerous that inflammation developing after recovery of consciousness may be unable to overcome them.

*Method of Placing Sutures.*—A corollary of the débridement procedure is that suturing must create as little nonviable tissue in the wound as possible. This necessitates using a minimum of sutures, which is accomplished by well-advised placing of sutures, and taking small bites so that the inevitable mass of strangulated tissue may be minimized.

*Electrosurgery.*—The experimental and clinical work of Ellis,<sup>34</sup> Magvary,<sup>35</sup> Hauberrisser,<sup>36</sup> and others has shown that wounds produced by electrosurgical units do not heal as well or as quickly or gain tensile strength as rapidly as similar wounds produced by a knife. The necrobiotic zone produced by the current must be dealt with before healing can take place, and, by analogy, to a lesser degree, the same holds true in wounds where hemostasis has been accomplished by the coagulating current. The disturbance is most marked in the skin, less so in fat and muscle, while in brain the burn seems to heal almost as well as a sharp wound.

*Infection.*—We may begin with the assumption that every wound, regardless of how it is made—operatively or accidentally—is contaminated. Meleny<sup>21</sup> has shown that even in a well-appointed operating room bacteria fall on a petri dish at a rate of 1 to 2 per minute and similar studies made elsewhere have confirmed these findings. Ives and Hirschfeld<sup>22</sup> have made cultures from clean operating rooms at various intervals from the time of skin incision to the time of closure and have found that positive cultures can be obtained from the subcutaneous tissues in practically 100 per cent. Even the peritoneum can be shown to be contaminated in almost 90 per cent. These wounds all healed by primary intention. When organisms gain entrance to tissues they do not at once begin to grow, but lie dormant for some time until they become acclimated to their new environment, and after this period of incubation has passed, growth occurs, and the wound is infected.

However, within the past few years, largely because of researches made by Meleny, Hart, Truesdale, and others, efforts are being made to sterilize or at least materially reduce the bacteria content of operating room air, with reduction of postoperative infection.

The presence of infection has been clearly shown to hasten the disintegration of catgut. Howes and Harvey<sup>23</sup> found that the chromic catgut of one manufacturer showed complete loss of tensile strength within six days, regardless of whether it was 20- or 40-day variety. The rapid digestion of 20-day catgut in apparently clean disrupted wounds, which has frequently been observed by many surgeons, may be attributed in numerous instances to the presence of some degree of infection which was not associated with perceptible suppuration. Suppurative or nonsuppurative infection may be localized to a small focus in a wound. If it occurs anywhere along the course of a continuous suture, the continuity of the catgut is lost at that point from rapid digestion. A disruptive force could then easily cause the remainder of the continuous suture to pull loose with subsequent separation.

Infection of a wound also may cause lysis of the fascia in which the sutures are placed, due to bacterial enzymes. This causes sutures to pull loose and affects silk-closed wounds as well as gut-closed ones.

*Drainage.*—In the American series of disruptions one-third of the patients in the reported cases were drained. When the European cases, except those of Madelung, are also considered, it is found that one-sixth of the total were drained. Colp<sup>24</sup> found that the incidence of disruption was 1.22 per cent in a series of 1,147 cases with drainage as compared with 0.84 per cent in 1,603 laparotomies in which there was no drainage. The use of a drain usually implies the presence of suppuration, except in instances in which the drainage is a precautionary measure as in cholecystectomy. It is a question whether the presence of intraperitoneal infection is not of more significance as an etiologic factor than the drain itself.

The technique of closure in the presence of a drain may influence the incidence of disruption to some extent. The use of a continuous suture would seem to be especially undesirable. The presence of intraperitoneal suppuration would certainly lead to infection of the tissue in proximity to the drain. The continuous suture which is tied adjacent to the drain would undergo rapid digestion in the presence of the infection at this point, and the continuity of the suture would be lost long before adequate healing had occurred in the rest of the wound. It would appear to be safer to use a separate stab incision for drainage whenever this is feasible. If the separate point of drainage is not feasible, one should at least put in several interrupted sutures adjacent to a drain before beginning a continuous suture of the remainder of the wound.

*Strain on the Healing Wound.*—The presence of postoperative complications which result in great intra-abdominal pressure has been emphasized as an important factor by Glasser,<sup>25</sup> Milbert,<sup>26</sup> and others. The constant pressure from distension and the sudden force of coughing, vomiting, retching, and hiccoughing undoubtedly play an important role in disruption. Crying in infants puts a tremendous strain on



the wound. When delirious or unruly patients get out of bed shortly after operation, they are likely to put an undue strain on the incision. Attempts to restrain such patients may result in an equally severe strain on their wounds if they thresh about. In coming out of anesthesia some patients are difficult to control. Two instances of audible breaking of the sutures under such circumstances have been reported by Ries,<sup>2</sup> and others have felt that the separation of the fascia in some cases undoubtedly dated back to this particular time.

The use of an abdominal binder has not been universally accepted as a method of relieving the tension which may be exerted on a wound during convalescence. The disadvantage of limitation of respiratory movement has been claimed by some to overcome any advantage that it might have in preventing strain on the wound. Most surgeons, however, feel that the use of a binder is a justifiable precaution either as a routine or in selected cases. Additional support may be obtained by using adhesive tape over the dressings.

*Anatomic Aspects of the Abdominal Wall.*—The upper abdomen is most frequently approached through a rectus incision. Because of the preponderance of transverse fibers in the posterior sheath of the rectus, it is frequently found that the sutures of any type may easily pull through this layer, as pointed out by White.<sup>27</sup> This is especially true when the patient has a thin posterior sheath or when the patient takes a poor inhalation anesthesia. When there is inadequate anesthesia this layer may be torn to shreds before the closure is completed. The importance of a "difficult sew-up" is stressed by Grace.<sup>28</sup> Koster and Kasman<sup>29</sup> believe that the low incidence observed in their series was due, to some extent, to the use of spinal anesthesia which permitted a more complete degree of relaxation during the closure of the wound.

When the sutures are placed close together in the anterior sheath at the same distance from the edge of the incision, it has been observed by White<sup>27</sup> and Ries<sup>3</sup> that the fascia may become so weakened by the multiple perforations that it will tear longitudinally, similar to the way postage stamps may be torn apart.

On the basis of anatomic considerations the McBurney incision appears to offer the safest approach to the abdomen even though disruptions following this incision have been mentioned by Maes, Boyce, and McFetridge<sup>30</sup> and Sokolov.<sup>6</sup>

*Tension Sutures.*—The use of tension sutures as a supplement to a catgut suture has been frequently recommended, especially in instances when the surgeon might anticipate delay in wound healing or early digestion of catgut from infection. There are some features about the use of tension sutures in wounds closed with continuous catgut which deserve analysis from a purely mechanical point of view. If a tension suture is tied too loosely, it will not give any support to the wound unless the overlying fascia separates. Then its support is mainly that of the skin and subcutaneous tissue. It would help prevent eviscera-

no final conclusions can be formulated from them. Two to three weeks after 13 guinea pigs were sensitized with sheep serum, all received, intracardially or intravenously, 0.5 c.c. to 1 c.c. of a catgut extract. While 7 animals presented symptoms which the author interpreted as evidence of anaphylaxis, 6 guinea pigs gave no symptoms whatever. Details of the preparation or the concentration of the extract are lacking in the original report, except for a single statement that the catgut was prepared from the dried intestine of sheep. In another series, 6 guinea pigs were "sensitized" with the catgut extract. No evidence, however, is presented to show that they were sensitive. Three weeks later the animals were given 1 c.c. of the extract either intracardially or intravenously. There was no reaction whatever in 5 animals, but there were symptoms suggestive of anaphylaxis in only 1 animal, and it survived. In a third series, 12 guinea pigs were "sensitized" with catgut extract, and about two weeks later were injected with sheep serum. There was no reaction in 9 animals, but death in 3. Autopsies, however, were not performed. A similarly injected control series was not described. A negative result was encountered in 4 of a total of 6 guinea pigs in which catgut was implanted intraperitoneally, and four to six weeks later they were injected with sheep serum. Marchesani states that strands of catgut buried intradermally in guinea pigs sensitized to sheep serum caused a greater leucocytic response than in normal guinea pigs.

Gratia and Gilson<sup>50</sup> state that fragments of catgut, either plain or iodated, implanted intraperitoneally in guinea pigs that had been sensitized to horse serum or sheep serum or both, caused an edematous, hemorrhagic, and "plastique" reaction. Frugoni,<sup>51</sup> however, was unable to confirm this either macroscopically or microscopically. The former authors interpreted their results as the Arthus phenomenon and suggested it as a cause of postoperative adhesions. The same result was obtained in rabbits sensitized to either horse serum, sheep serum, or catgut, after which a catgut emulsion, desiccated horse serum, and desiccated sheep serum were introduced respectively into the peritoneal cavity.

Moriconi<sup>52</sup> was unable to demonstrate any serologic manifestations referable to immunity in rabbits that had been subjected to the absorption of either plain or iodated catgut. Precipitin tests on their serum were completely negative. Neither was he able to produce any symptoms of general or local sensitivity in rabbits subjected to the repeated absorption of catgut. In a criticism of Moriconi's work, Kraissl<sup>32, 45</sup> states, "It is to be noted, however, that he was working with rabbits which are rather difficult to sensitize." In reality, rabbits are readily sensitized, while guinea pigs are sensitized with difficulty but demonstrate anaphylaxis more readily than rabbits.

Frugoni<sup>51</sup> was unable to demonstrate any serologic changes in the serum of rabbits that had received catgut extract intravenously or cat-

gut implanted intraperitoneally. Precipitin tests were entirely negative. Attempts to produce anaphylactic shock in guinea pigs that were sensitized with sheep serum and then injected intravenously with catgut extract were likewise negative, as had been shown previously by Moriconi.<sup>52</sup> Attempts to produce anaphylactic shock by the intravenous injection of sheep serum in guinea pigs that had catgut implanted in the peritoneal cavity 60 days previously were completely unsuccessful. Frugoni obtained identical reactions, both macroscopically and microscopically, when catgut was implanted intraperitoneally in control rabbits, in rabbits sensitized with sheep serum, and in those having been previously treated with catgut. The wounds healed per primam and there was no increased local reaction. His results were so completely negative that he ruled out any antigenic action of catgut.

Babeock<sup>53</sup> studied the macroscopic reactions of plain and chromic catgut and other suture material (silk, horse hair, dermal sutures, silver and alloy steel wire) by implanting small sections of these in the sterilized skins of 120 normal patients. Inasmuch as all materials in every patient presented a reaction with the same characteristics, limited to the site of the implantation, but some to a lesser degree, this does not prove that the reactions were allergic or anaphylactic in character.

Tripp<sup>54</sup> reports the case of a patient who developed asthma while convalescing from a second operation in which chromic catgut had been used. It is not stated what suture material had been employed in the first operation five years previously. The asthma, however, totally disappeared after a few weeks. He reports this as a case of catgut sensitivity, and yet no tests were made to confirm his assumption.

Kraissl<sup>45</sup> states, "It is possible to sensitize guinea pigs to catgut and to produce disruptions of laparotomies sutured with this material." Guinea pigs were used because "rabbits are rather difficult to sensitize." It is a well-known fact that tissue sensitivity can be produced more easily in rabbits than in other laboratory animals. On the other hand, typical anaphylactic shock can be more readily induced in the guinea pig than in other animals. "Nineteen guinea pigs were sensitized with plain and chromic catgut. This was done with intraperitoneal injections of a colloidal suspension, by burying catgut itself subcutaneously, and by closing abdominal laparotomies with catgut. In addition one was sensitized by intracardiac injection and another by repeated intradermal injections." Intradermal injections of approximately 0.1 c.c. of catgut extract containing 0.13 mg. per cent total nitrogen was used to determine sensitivity. Laparotomy incisions were closed with through-and-through bolt sutures of plain and chromic catgut. Six of the 19 incisions disrupted, 3 being sewed with plain catgut and 3 with chromic catgut; 1 of each being sensitized to the other type of catgut. Only 3 had positive skin tests, although data are lacking describing the appearance of a positive test. Five incisions disrupted between the second and fourth postoperative days, and 1 on

the eighth postoperative day, and 4 healed abnormally. None of the incisions in 6 control guinea pigs disrupted, but 1 healed abnormally.

From this experiment several sources of criticism are readily discernible. No mention is made of any aseptic technique employed during the execution of the laparotomies. That the incisions were infected is obvious from the photographs which are submitted as evidence of disruption. No mention is made of the appearance of the wounds prior to disruption. Secondary closures were apparently not attempted. No attempt was made to produce anaphylactic shock in the sensitized animals, neither were any serologic tests performed to test for the formation of precipitins.<sup>55</sup>

In a later study,<sup>56</sup> which includes the experiment previously described, Kraissl found that of 28 guinea pigs sensitized to plain catgut, 10 disrupted their incisions: 1 on the first postoperative day, 2 on the second, 1 on the third, 4 on the fourth, 1 on the seventh, and 1 on the eighth postoperative day. Nine healed abnormally, while 9 healed normally. In a group of 16 guinea pigs sensitized to chromic catgut, 5 disrupted between the second and sixth postoperative day, 4 healed abnormally, and 7 healed normally. Of 8 animals sensitized to chromic acid, 2 disrupted and 3 healed abnormally, while of 26 controls only 1 healed abnormally.

Langston,<sup>60</sup> impressed with the frequency of poor healing in third stage thoracoplasty wounds among persons with wounds closed with catgut in two previous stages, prepared a catgut extract with which he performed skin tests. Twelve per cent of the surgical patients had positive cutaneous tests, although the only description of a positive test is that it was maximal in fifteen to twenty minutes and faded after forty-five minutes. After two thoracoplasties using catgut, 70 per cent of the persons tested had positive skin tests. The evidence of catgut sensitivity is rendered inconclusive, however, by failure of attempts to demonstrate passive transfer of sensitivity and absence of precipitins from blood serum and wound fluid in "sensitive" persons.

Catgut consists of the submucosa of the small intestine of sheep. In its manufacture, the intestine is split longitudinally usually into three strips. The mucosa is then scraped off from the inner side, then the serosa and the two muscular layers are scraped off from the outer side, thus leaving only the submucosa. The strips of submucosa are then subjected to alkaline baths for the purpose of neutralizing any acid or toxic substance which may have been embedded in them as a result of the digestive process. Titration tests are then applied to prove that the tissue is neutral in reaction. The strips of submucosa are then spun into a cord called *catgut*, which is chemically pure collagen. According to Bodansky,<sup>57</sup> connective tissue contains about 60 per cent water and 40 per cent solids. Of the latter, about 0.5 per cent consists of inorganic matter. The principal organic constituent of fibrous tissue is the albuminoid collagen, which composes about 32 per cent of the tissue, the

remaining 6.7 per cent being made of elastin, an albuminoid, ether soluble lipids, and nonprotein constituents. Upon hydrolysis, collagen is transformed into gelatin, which is interesting because of the complete absence of three amino acids, tryptophan, cystine, and tyrosine. A fourth amino acid, histidine, is present only in exceedingly small amounts.<sup>53</sup> Ziegler and Clark<sup>59</sup> state that the x-ray diffraction pattern of the catgut ligature is quite similar to that of gelatin and collagen. Gelatin, in so far as these authors are aware, does not give typical immunologic reactions. Silk, silkworm gut, women's hair, and horse's hair contain much cystine and glycocol.<sup>48</sup>

Human tissues absorb catgut by means of tryptic ferments of leucocytic origin. These ferments do not leave intact any albuminoid residue which could act in an antigenic capacity, as has been shown by Reil.<sup>48</sup> After catgut is rendered soluble, it is no longer collagen but amino acid. Frugoni<sup>51</sup> demonstrated by chemical analysis that the substances present in a catgut extract are not albumins but albumoses which are without antigenic power and, therefore, incapable of causing sensitization.

#### EXPERIMENTAL STUDIES

The present experiments\* were carried out in order to determine whether domestic catgut could produce any evidence of sensitivity, either general or local, in either rabbits or guinea pigs. It was decided at the outset to use a standard brand of boilable catgut, selected at random for the surgical supply rooms of the Johns Hopkins Hospital.

Sixty rabbits and 80 guinea pigs have been used in the experiments here reported. In the first experiment, 12 rabbits and 12 guinea pigs were subjected to six implants of plain catgut at intervals of one month. The procedure was as follows. The day prior to operation the entire abdomen and flanks of the animal were clipped and shaved. Under ether anesthesia, a wide operative field was cleaned with ether, iodine, and alcohol, after which the operative field was appropriately draped with sterile towels. Rigid asepsis was observed throughout. The instruments and ampoules of catgut were sterilized by boiling for 10 minutes. A paramedian incision 3 to 4 cm. in length was made through the skin and subcutaneous tissue. The muscle was then divided by blunt dissection, and the peritoneum opened the full length of the incision. The catgut before its insertion was softened in physiologic salt solution. A continuous suture of plain No. 0 catgut was used to close the peritoneum. Interrupted sutures of No. 0 catgut were used to close the muscle and skin respectively. Square knots were tied and cut moderately close. Every effort was made to reproduce the technique employed in the operating room, except for the fact that no gauze dressing was applied over the incision. Occasionally, however, the incision was sealed with collodion. One month later, the same process was repeated, using the back of the

\*Some of these experiments were previously published in the Bulletin of the Johns Hopkins Hospital<sup>60</sup> with whose permission they are here presented.

animal. Here, likewise, a paramedian incision was made, and carried down through the heavy musculature of the back. The muscle and fascia were approximated with interrupted sutures of plain No. 0 catgut, the skin edges being closed on six occasions at intervals of one month, alternating the abdomen with the back for the operative site.

The second experiment, using 12 rabbits and 12 guinea pigs, was similar to the one above except for the fact that chromic No. 0 catgut of the sizes indicated was employed.

Lest it be said that an insufficient quantity of catgut had been implanted in the previous experiments, even though an amount equivalent to that employed in routine surgical procedures was used, a third experiment was performed in which, instead of simply making incisions and closing them with plain or chromic catgut respectively, in the present experiment two or three strands of catgut 3 to 4 cm. in length were buried either intramuscularly in the back or subcutaneously in the abdominal wall. In 6 rabbits and 6 guinea pigs, two or three strands of plain No. 1 catgut were buried on six occasions at intervals of one month beginning with the back and alternating with the abdomen. The incisions were closed with interrupted sutures of plain No. 0 catgut. A similar number of animals was subjected to the absorption of two or three strands of No. 1 chromic catgut at intervals, 30 days for one month. The incisions were closed with chromic catgut in the manner previously outlined. Where plain catgut was buried, plain catgut was used to close the wounds and vice versa.

## RESULTS

In both rabbits and guinea pigs using either plain or chromic catgut, the incision in every instance healed per primam following each operation. There was no evidence whatever of any increased local reaction as compared with normals. There were no disruptions, no infections, and no evidence of either local or general sensitivity. Prior to each operation in the rabbits, precipitin tests for antibody production were carried out. In addition, intradermal tests in both rabbits and guinea pigs with suitable controls were performed, by injecting 0.1 c.c. of a catgut extract. These, also, were completely negative.

The catgut extract was made in the following manner. Ten skeins of plain No. 3 catgut were pulverized by grinding in an Arabian coffee grinder. After placing the catgut powder in a heavy liter bottle, 500 c.c. of sterile physiologic saline solution and pyrex chips were added. The container was then placed in a mechanical shaker for 4 hours. This yielded a colloidal suspension of catgut particles in a saline vehicle. The suspension was then placed in a vacuum dryer; 0.1 Gm. of the powder thus obtained was placed in glass ampoules covered with xylene and the ampoules sealed in a flame. The tubes were then autoclaved under oil for one hour. This is the process generally employed by manufacturers in the sterilization of catgut. Using sterile

technique, the tops of the ampoules were then removed and a cotton plug inserted, thus allowing the xylene to evaporate. This completed, 5 c.c. of sterile physiologic saline solution were then added to each tube. This dissolved the greater portion of the catgut powder. The resulting clear, sterile supernatant fluid was then withdrawn and placed in sterile serum bottles or tubes. Total nitrogen determinations by the micro-Kjeldahl method revealed not less than 50 mg. per cent of this element.

In another experiment, 3 rabbits had three strands of sterile, chemically pure catgut implanted intramuscularly in the back on three occasions at intervals of one month; 3 rabbits had 10 to 12 gr. of chemically pure powdered catgut deposited in the peritoneal cavity on three occasions at monthly intervals through an incision 4 to 5 cm. in length; 3 had 10 to 12 gr. of powdered commercial plain catgut implanted in a similar manner; 3 had 10 to 12 gr. of powdered chromic catgut implanted intraperitoneally; 3 rabbits had a skein of plain No. 0 catgut buried intraperitoneally on three successive months, and 3 rabbits had a skein of No. 0 chromic catgut implanted intraperitoneally on three occasions. In each instance, the incision was closed in layers with interrupted sutures, No. 0 catgut, of the type implanted.

Never was there any evidence of either a local or general reaction, and the incisions in each instance healed per primam. It was interesting to find that at the end of a month no evidence whatever could be found of the plain catgut or the chemically pure catgut, regardless of the form in which it was deposited. In those animals that received the skein of chromic catgut, on only two occasions was it possible to find any vestige of the skein. In these the remnants were found with difficulty as a tiny white mass embedded in the gastrocolic omentum. Microscopic section revealed these to be almost solid masses of leucocytes and macrophages, and it was impossible to identify anything discernible as catgut. Inasmuch as no trace of the catgut could be found after one month, the peritoneal cavities were examined thereafter in 10 to 12 days after the second catgut implant. At this time the powdered catgut could be recognized as minute flecks on the surface of the intestine which was slightly reddened. The reaction, however, was no more marked than that found in 3 similarly treated control animals. The animals in which the skein of catgut had been deposited, either plain or chromic, showed even less reaction, limited to the immediate vicinity of the catgut implant, i.e., either between loops of small intestine or in the gastrocolic ligament. The plain catgut was found as a mass of rather friable white material, while the contours of the chromic skeins were still well differentiated, and the strands still bore considerable tensile strength. By the end of the third week only traces of the powdered catgut could be found between the loops of adherent intestine and there was no longer any reaction whatever. It should be made clear that there were no adhesions but simply a coherence be-

tween adjacent loops of intestine, and limited only to the site of the catgut implant. The skeins of plain catgut presented the same appearance except for being considerably smaller in size than after the second week. The chromic catgut skeins at the end of the third week appeared as a mass of friable white material. And as was previously stated, at the end of four weeks no trace whatever of the plain catgut could be found, while in 2 instances remnants of chromic catgut skeins were recognized as tiny, white friable masses.

One month after the third deposit of catgut, the peritoneal cavities were again examined. Numerous friable adhesions between adjacent loops of bowel were found limited to the site of the catgut deposits. Although some of the animals have been sacrificed in the interim, 6 of the rabbits are still living and appear perfectly normal more than a year after the last catgut had been implanted. Hence, we are unable to confirm the supposition of Gratia and Gilson<sup>50</sup> that catgut causes any more adhesions than other suture materials, or that catgut is a prominent cause of postoperative adhesions. Precipitin tests performed at monthly intervals on the serum of the rabbits for antibody production were entirely negative. Intradermal tests for local sensitivity were also negative.

To test for anaphylaxis, 42 guinea pigs were used. Twelve were injected intravenously in the jugular vein with 1 c.c. of our catgut extract; 12 were injected intravenously with 1 c.c. of Kraissl's extract of plain catgut;\* and 12 were injected intravenously with 1 c.c. of Kraissl's chromic catgut extract;\* 6 guinea pigs were used as controls in which saline solution was injected. After three to four weeks, all animals were again injected intravenously with 1 c.c. of the prescribed extract. For the intravenous injections, the jugular vein was exposed without anesthesia, extreme caution being exercised to avoid bleeding. Not a single reaction was encountered.

To determine conclusively whether any increased local reaction occurred around a single intradermal strand of catgut in animals submitted to the previous absorption of catgut, either plain or chromic, 6 rabbits and 6 guinea pigs had laparotomies performed and two or three strands of plain No. 0 catgut buried subcutaneously. The incision was closed in layers using plain No. 0 catgut. Six rabbits and 6 guinea pigs were similarly treated burying two or three strands of chromic catgut. Three rabbits and 3 guinea pigs were injected intravenously with 1 c.c. of the catgut extract. After one month, using rigid asepsis, a strand of either No. 0 or 00 catgut about 2 cm. in length was inserted intracutaneously, using an atraumatic needle, in each flank. In those animals in which plain catgut had been previously buried, the intradermal implant was likewise of plain catgut, and vice versa. The sites of implant were observed macroscopically at the end of 24 to 48 hours respectively, and the sections of skin containing the catgut implant

\*Extracts furnished by Dr. C. J. Kraissl.



were removed for microscopic study. The same procedure was performed in 6 normal guinea pigs and 6 normal rabbits.

The site of the catgut implant was always discernible as a small erythematous streak. Never was there any greater macroscopic reaction in those animals that had previously been treated with catgut than in untreated controls. Microscopic sections revealed in both the previously treated and the normal controls a positive chemotactic leucocytic response, but in no instance was the leucocytic emigration greater in the rabbits or guinea pigs which had been previously treated with catgut as compared with normal control animals. (See Figs. 1 to 6.)

#### DISRUPTION OF ABDOMINAL WOUNDS

There has been no unanimity of opinion as to what roles the various factors influencing wound healing play in disruption of abdominal wounds. The following is a summary of the opinions of the authors who have studied the problems.

Freeman<sup>61</sup> believes that the primary cause is insecure peritoneal closure, permitting the edematous omentum to act as a wedge and produce separation of the peritoneum and then of the muscle and fascia. Starr and Nason<sup>62</sup> also believe the omental wedge to be the primary cause, but they list several factors which they believe important in contributing to disruption, namely, carcinoma, retching and straining, hyperventilation, and increased intra-abdominal pressure. Sokolov,<sup>6</sup> after a study of 725 cases reported by 187 surgeons, reached the conclusion that since disruption of wounds seemed to be more frequent in the early part of the year, it was to be explained on the basis of general fatigue and relative vitamin C deficiency during the winter months. He found that even the use of silk in place of catgut does not prevent wound disruption. He states: "The principal causative factor is always the patient's tissue qualities and their reduced tonus as affected by the disease." Erdmann<sup>63</sup> ascribes disruption of wounds to "tissue hunger" with resulting rapid digestion and absorption of catgut. He has noted the condition chiefly in cases of anemia due to such things as tuberculosis, carcinoma, hemorrhage, infections, and malignancies of the female pelvic organs. Meleny and Howes<sup>31</sup> stressed the fact that care in suturing must be concentrated on the peritoneum and posterior sheath, together with the use of retention sutures. Colp<sup>21</sup> believes that the crux of the problem rests in the failure of the regenerative powers of the tissues to promote firm healing. He states: "The primary disease undoubtedly is the most important feature underlying the etiology of wound rupture. While it is true that rupture of the abdominal wall may occur in any disease affecting the peritoneum and its contents, it appears to be associated more frequently with some diseases than with others. It would seem logical to suppose that illnesses of a protracted nature attended by emaciation, anemia, cachexia, and weakness, and those of acute and chronic intoxications associated

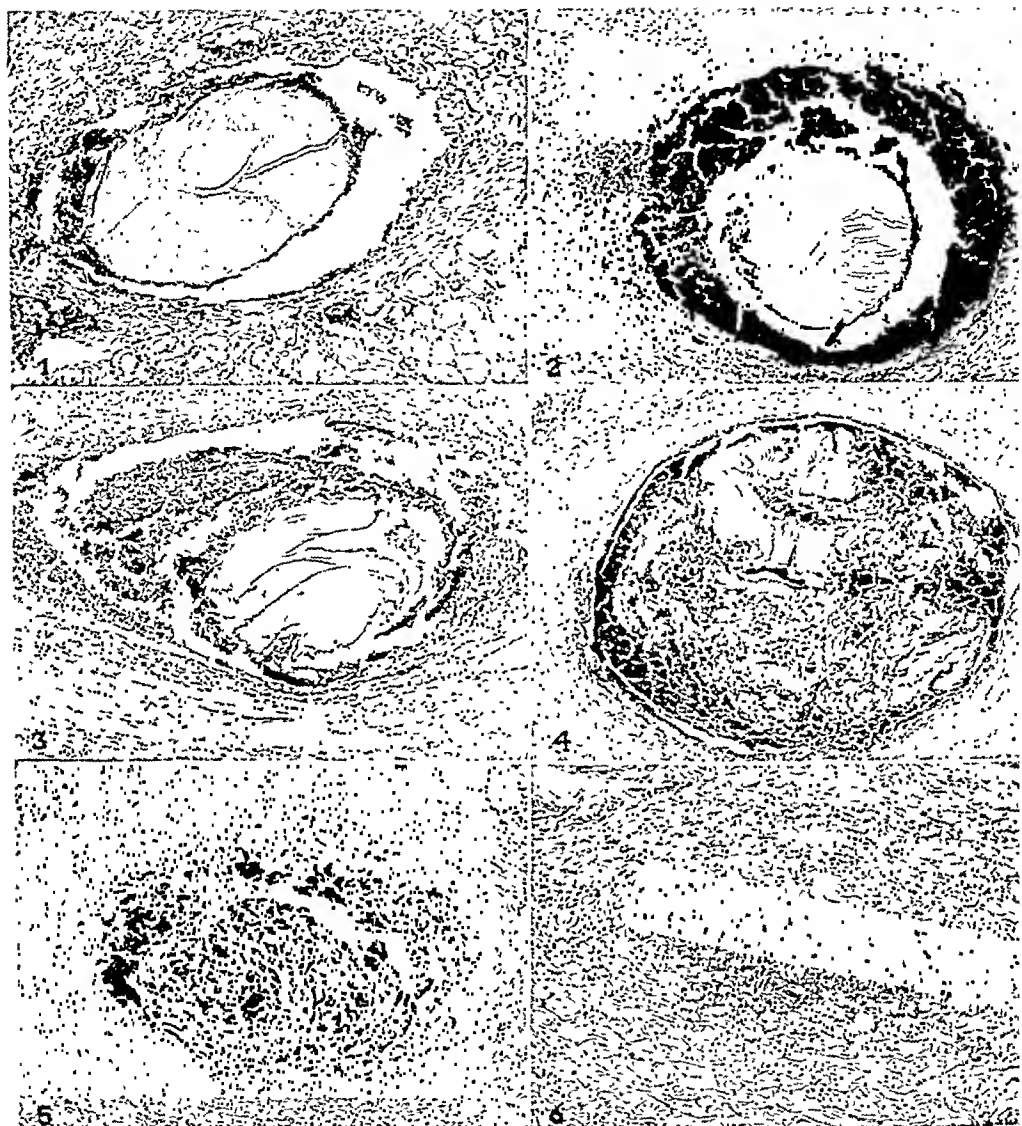


Fig. 1.—  
ously into  
an atrau-  
tion in re

rand of plain No. 1 catgut implanted subcutane-  
ously previously. The catgut was inserted with  
technique. There is beginning leucocytic prolifera-  
of a foreign body.

Fig. 2.—Microscopic section of strand of plain No. 1 catgut implanted 5 days  
previously into the back of a rabbit. The leucocytic response is marked, filling the  
dead space caused by the needle. Leucocytes have begun to invade the twisted strand  
of catgut.

Fig. 3.—Photomicrograph of strand of catgut buried 12 days previously. The  
leucocytic response has subsided considerably but the leucocytes have invaded the  
interior of the strand which is now beginning to fragment. The catgut strand at  
this stage still possesses considerable tensile strength.

Fig. 4.—Microscopic section of strand of catgut implanted 21 days previously. The  
invading leucocytes together with their tryptic and cryptic ferments have caused  
complete fragmentation and partial digestion of the catgut strand. At this stage  
the strand of catgut possesses no tensile strength.

Fig. 5.—Photomicrograph of catgut strand buried 30 days previously. It has un-  
dergone complete digestion. The leucocytic response is still marked.

Fig. 6.—Microscopic section taken at the level of catgut implant 40 days previously.  
The catgut strand has been completely digested, the leucocytic response is disappear-  
ing, and the tissues are approaching normal.

with long bouts of temperature, might devitalize the individual sufficiently to interfere with the reparative powers of the tissues and wound healing. Malignant tumors with their undeniable debilitating effect on the body are responsible for most wound disruptions. Certain benign growths like uterine fibroids are often attended with harmful systemic affections, particularly secondary anemia, definitely impairing proper metabolism."

White<sup>27</sup> says that predisposing causes are senility, decrepitude, malignancy, jaundice, and a peculiar body tissue function that dissolves catgut earlier than usual. Also, that the exciting causes are constant coughing, hiccupping, straining, distension, undue abdominal strain, and infection. Heyd<sup>61</sup> recommends as preventive measures (a) complete hemostasis of the wound; (b) relaxation of the abdominal walls when closure is being made; (c) avoidance of undue trauma; (d) elimination of dead space which favors collection of serum; (e) absolutely aseptic technique; and (f) accurate coaptation of the peritoneum. Harvey<sup>65</sup> believes that the constitutional or general condition of the patient, such as the presence of malnutrition, and particularly anemia, may lead to weakening of the wound. He ascribes three essential reasons for disruption of wounds: (1) failure to close properly the posterior rectus sheath; (2) the presence of foreign material in the wound, including infection or accumulation of serum in dead spaces as a result of inaccurate apposition of the tissues; and (3) the use of too large sized catgut in too large a quantity, which thus acts as foreign material. Baldwin<sup>66</sup> stresses the importance in any abdominal case of re-enforcing the dressings by a semitennis or many-tailed binder applied snugly around the abdomen. He also points out the value of using stay sutures, which he advocates leaving in place long enough to prolong the period of maintenance of tissue holding, and thus insure firm union. He frankly admits that he encountered wound disruption when he removed the stay sutures after 7 days; also when the sutures were removed after 10 days, and again when he removed the sutures at the end of 12 days. However, he then adopted the policy of leaving the stay sutures in place for 14 full days and supporting the abdomen by a firm many-tailed binder so that it can be properly adjusted and there will be no slipping. Even after the removal of the stay sutures at the end of 2 weeks, the abdominal binder is reapplied and kept in place for another week. During more than 35 years since adopting this technique and during which period he has performed 16,465 abdominal operations, not one of these patients of Baldwin's developed wound disruption or postoperative hernias.

Singleton<sup>67</sup> recommends the use of a modified Sloan transverse incision in the upper abdomen, because it is anatomic in that no important nerves or blood vessels are cut and the muscles and fascia are separated in the direction of their fibers. Such a wound, he states,

may be closed without tension; and in a series of nearly 300 operations in which he has used this technique, there have been no disruptions and no postoperative hernias. Maes, Boyce, and McPetridge<sup>30</sup> state that regardless of age, sex, personal equation, operative risk, underlying pathology, anesthesia, or any similar consideration, wound disruption occurs in all cases because of one fundamental consideration: some interference with the process of wound healing. They conclude that rupture is possible with any type of suture material and in any type of closure. They believe that catgut used with the "silk technique" is as safe as silk, and they question the wisdom of advising the general use of silk. Milbert<sup>26</sup> reviewed 1,560 laparotomies to determine the incidence of disruption of abdominal wounds. He found 20 cases of partial or complete separation of the abdominal wall in the fourth, fifth, and sixth decades of life. Its incidence was especially high in cases of chronic infection and cases of malignancy with cachexia and anemia. Of the 20 cases of disruption, drainage was established in 9. He emphasizes the importance of intra-abdominal pressure as a causative factor in wound disruption, especially the constant or explosive type of increased intra-abdominal pressure which is associated with coughing. He concludes that dehydration, malnutrition, and obesity favor the disruption of wounds, and emphasizes the importance at operation of strict asepsis, limitation of tissue trauma to the minimum, and accurate approximation of the severed tissues. He states that the anesthesia must give sufficient relaxation of the muscles to permit good closure. Abdominal binders should be used as their benefits overbalance their disadvantages.

Over a period of six consecutive years in which spinal anesthesia was used for more than 7,800 laparotomies, Koster and Kasman<sup>29</sup> encountered wound disruption in only 0.22 per cent of their cases. All wounds were closed with continuous sutures, No. 2 plain catgut for the peritoneum and No. 2 chromic catgut for the fascia, the muscle not being sutured separately. They find that spinal anesthesia affords maximal relaxation of the tissues, and thereby facilitates the operative procedure so that the tissues receive the least amount of trauma. These authors conclude that (1) abdominal operations should be performed aseptically with maximum wall relaxation; (2) undue trauma should be avoided; (3) complete hemostasis should be attained; (4) accurate coaptation of the layers of the wall without dead space should be secured; (5) postoperative disruptive forces, as cough, vomiting, and hiccough, should be strenuously combated; (6) wounds should be inspected for a possible subcutaneous separation particularly before the sutures are removed. The attention given these details will affect the incidence of disruption. Jenkins<sup>8</sup> has pointed out that the inherent weakness of the posterior sheath and the prevalent use of plain catgut, which lasts only five to six days under any condition, for closure of

this layer, are undoubtedly factors which are responsible for the frequency of disruption in the upper abdomen in the American cases. He also states that disruptions have been found to occur regardless of whether wire, linen, silk, silkworm, or catgut is used.

Kraissl and co-workers<sup>50</sup> analyzed 30 cases in which the patients survived wound disruption at the Presbyterian Hospital since 1930. No mention is made of wound disruptions occurring in cases in which silk or other suture materials were used. Of these 30 cases, 24 wounds were infected, and only 4 were not complicated by distention, cough, hiccough, pneumonia, vomiting, acute intestinal obstruction, etc. Kraissl states that "a history of allergy or a previous operation increases the likelihood of an individual being sensitive to catgut." "All 5 cases which gave a history of allergy showed a positive skin test to one or more of the extracts," i.e., plain, chronic, or chronic acid extract. "Twelve of the whole group had a previous operation and 7 of these gave a positive reaction. Of the 18 which gave no history of operation, 12 had a positive skin test indicating that this factor was of little importance in this group. However, it may be possible that the reaction to the catgut causing the disruption may have desensitized the individual resulting in a negative response to the skin test."

#### WOUND DISRUPTION AT THE JOHNS HOPKINS HOSPITAL

Thirty-five cases of abdominal wound disruption have occurred on the surgical, gynecological and obstetrical services of the Johns Hopkins Hospital since January, 1937, a period of almost 7 years. Catgut was used for closure in 14 cases, silk in 19 cases, and steel wire in 2 cases. It should be made clear that this proportion is in no way representative of the usage of either type of suture material in this institution, for silk is used almost exclusively on the surgical service, while catgut is preferred on the gynecological and obstetrical services. Of these 35 cases of abdominal wound disruption, 8 had a previous abdominal operation, 7 of which had been performed in this hospital, catgut being used for closure in 4 instances and silk in 3 cases. The interval between the first and the second operation varied between 3 and 15 years. Wound healing at the time of the first operation is said to have proceeded in a normal manner. Only 9 of the 35 patients in whom wound disruption occurred are said to have been in good physical condition at the time of operation. There was gross contamination of the peritoneal cavity in 29 instances at the time of the original operation, and of these, the wounds in 15 cases were grossly infected at the time of the disruption. The main causative organism was *Bacillus coli*. Drainage was established in 6 cases, and retention sutures were employed in 16 cases. The age of the patients ranged between 20 and 80 years; 22 cases (63 per cent) occurring in patients over 50 years of age (see Table I).

TABLE I

AGE PERIOD	YEARS 20-29	YEARS 30-39	YEARS 40-49	YEARS 50-59	YEARS 60-69	YEARS 70-79	TOTAL
Number of disruptions	6	3	4	9	11	2	35

The greatest number of disruptions occurred following gastric resection for malignant disease of the stomach and duodenum, and following pelvic operations, including cesarean section. The 6 patients in whom disruption occurred (in patients under 30 years of age) were operated upon following gunshot wounds of the abdomen or cesarean section (see Table II).

TABLE II

PRIMARY DISEASE	DISRUPTIONS
Malignant disease of stomach and duodenum	8
Benign ulcers of stomach and duodenum	2
Pelvic operation including cesarean section	8
Gunshot wounds of abdomen	4
Intestinal obstruction	3
Carcinoma of pancreas	1
Exploration of common duct	2
Diverticulitis of colon	2
Omentopexy for cirrhosis	1
Neoplasm of large intestine	4

In our series of 35 cases, 16 instances of abdominal wound disruption occurred on the seventh postoperative day, 7 cases each on the sixth and eighth postoperative day respectively, making a total of 30 cases (85 per cent) in which disruption occurred in the quiescent phase or "lag period"—extending to the eighth postoperative day (see Table III). These observations confirm those of Harvey and Howes<sup>11</sup> who found that the first 6 or 7 days of wound repair were the critical days.

TABLE III

POSTOPERATIVE DAY OF WOUND DISRUPTION	4TH	5TH	6TH	7TH	8TH	12TH	13TH	TOTAL
Number of cases	1	2	7	16	7	1	1	35

*Incisions.*—As evidence that disruption occurs through various types of incisions, 10 disruptions occurred through a lower midline incision, 8 through the upper midline, 9 through a right rectus, 7 through a left rectus, and 1 through a subcostal transverse incision. In 21 instances, the peritoneum or posterior sheath of the rectus was closed with continuous sutures of catgut. As stated previously, there was gross contamination of the peritoneal cavity in 29 instances, and 15 were grossly infected at the time of the disruption. Drainage was established in 6 cases and retention sutures were employed in 16.

*Anesthesia.*—Gas-oxygen-ether anesthesia was used in the primary operation in 27 patients, spinal anesthesia being used in 6 patients, while sodium pentothal and local infiltration of procaine were each used in a single case.

*Secondary Closure.*—Secondary closure of the disrupted wound was performed as soon as possible after the disruption. Except in 4 instances, catgut supplemented with retention sutures was used for the secondary closure. Death occurred as a result of the disruption in only 2 instances, and 1 of these patients died with generalized peritonitis, the causative factor in the disruption of the wound.

#### CLINICAL STUDIES

We have had an opportunity to test for local catgut sensitivity in each of these 35 cases of abdominal wound disruption within a relatively short period after the disruption took place, regardless of the suture material used either in the operation or for closure of the abdominal wall. In 10 of the 19 cases in which silk was used for closure of the abdominal wall, catgut was used in some phase of the operation. Each patient was injected intradermally on the volar surface of the forearm with 0.1 c.c. of Kraissl's plain and chronic catgut extracts. Similar quantities of extract diluted 1 to 10 were injected intracutaneously in the opposite forearm. The tests, performed within a short period after the disruption, were negative. Furthermore, we have tested 100 patients preoperatively in a similar manner, likewise with negative results. The sites of inoculation were observed constantly for two hours and at daily intervals for several days. These same patients were again tested 3 to 4 weeks after operation, when it was assumed that the greater part of the catgut had been absorbed. These tests were completely negative.

From our analysis and a careful review of the literature, one can definitely state that disruptions occur regardless of the suture material used. Disruption in each instance was due to the markedly increased intra-abdominal pressure, either of the constant type resulting from ileus, peritonitis, etc., or more especially from the violent explosive type caused by sneezing, coughing, hiccupping, vomiting, retching, or straining. There was no evidence whatever of any increased local or general reaction. Disruption in 5 instances, in conjunction with the increased intra-abdominal pressure, might possibly have been due to insecure peritoneal closure, permitting the omentum or a loop of intestine to act as a wedge producing separation of the peritoneum and then of the muscle and fascia. It seems not unlikely that even in these 5 instances had not the increased intra-abdominal pressure been present, the omentum would never have herniated, and disruption would not have occurred. Although nonabsorbable retention sutures will not necessarily prevent disruption, they will give added support, and will prevent evisceration.

In not a single instance was there anything to suggest an increased local or general reaction. Inasmuch as the secondary closures were performed with catgut, supplemented with retention sutures, except

in 4 instances, and with healing proceeding in a normal fashion, one can disregard the supposition of catgut allergy as a cause of postoperative wound disruption.

### CONCLUSIONS

From a consideration of the experiments performed, the cases of wound disruption analyzed, and the literature reviewed, one arrives at certain conclusions: (1) It was impossible for us to sensitize either guinea pigs or rabbits to commercial catgut or to an extract prepared from catgut. (2) No evidence of either local sensitivity or general reactions could be elicited in guinea pigs or rabbits subjected to the previous absorption of catgut. (3) It was impossible to produce anaphylactic shock by the intravenous injection of a catgut extract into guinea pigs that had been previously treated with either catgut or catgut extract. (4) Serologic tests for antibody production in previously treated animals were negative. (5) No disruptions occurred in either rabbits or guinea pigs which had been previously treated with catgut. (6) Although catgut implanted intradermally in both rabbits and guinea pigs causes an inflammatory response, the leucocytic emigration is no greater in those animals that had been previously treated with catgut or catgut extract. Therefore, one can finally conclude that although catgut, just as any other suture material, acts as a foreign body and causes a leucocytic response, it does not act as an antigen, nor is it capable of producing antigenic irritative phenomena. (7) Of 35 cases of postoperative wound disruption analyzed, the primary cause of the disruption was found to be markedly increased intra-abdominal pressure, and there was no evidence whatever of so-called catgut allergy. Disruptions occur regardless of the suture material employed, principally in the fifth, sixth, and seventh decades in patients affected with malignant tumors.

It is in no sense the intent of the present article to imply that catgut should be used in preference to silk as a suture material. The experiments bear simply on the question of hypersensitivity to catgut and they indicate that the use of catgut carries no danger referable to hypersensitivity to this material.

### REFERENCES

1. Brehauer, J.: Three Cases of Rupture of the Abdominal Wall, *Am. Gynaec. & Obst. J.* 14: 324, 1899.
2. Madelung, O.: Ueber den postoperativen Vorfall von Baueingeweiden, *Arch. f. klin. Chir.* 77: 347, 1905.
3. Ries, E.: On Postoperative Separation of Laparotomy Wounds, *Am. J. Obst.* 60: 569, 1909.
4. Holtermann, C.: Ueber postoperative Dehiscenz frischer Laparotomiewunden mit Vorfall von Bauchhöleninhalt, *Zentralbl. f. Gynäk.* 49: 213, 1925.
5. Shipley, A. M.: Broken-Down Abdominal Incisions. A Method of Closure, *Ann. Surg.* 82: 542, 1925.
6. Sokolov, S.: Postoperative Rupture of Abdominal Wounds With Protrusion or Prolapse of the Viscera, *Vestnik khir.* 65: 219, 1931.



7. Carrel, A.: Process of Wound Healing, *Proc. Inst. Med. Chicago* 8: 62, 1930.
8. Jenkins, H. P.: Clinical Study of Catgut in Relation to Abdominal Wound Disruption, *Surg., Gynec. & Obst.* 61: 648, 1937.
9. Clark, A. H.: The Effect of Diet on the Healing of Wounds, *Bull. Johns Hopkins Hosp.* 30: 117, 1919.
10. Thompson, W. D., Ravdin, J. S., and Frank, J. L.: The Effect of Hypoproteinemia on Wound Disruption, *Arch. Surg.* 36: 500, 1938.  
Thompson, W. D., Ravdin, J. S., Rhoades, J. E., and Frank, J. L.: Use of Lyophile Plasma in the Correction of Hypoproteinemia and Prevention of Wound Disruption, *Arch. Surg.* 36: 508, 1938.
11. Harvey, S. C., and Howes, E. L.: The Effect of High Protein Diet on the Velocity of Growth of Fibroblasts in the Healing Wound, *Ann. Surg.* 91: 611, 1930.
12. Howes, E. L., Sooy, J. W., and Harvey, S. C.: The Healing of Wounds as Determined by Their Tensile Strength, *J. A. M. A.* 92: 42, 1929.
13. DuMontier, J. J.: Resistance of Healing Wounds to Infection, *Surg., Gynec. & Obst.* 56: 762, 1933.
14. Lanman, T. H., and Ingalls, T. H.: Vitamin C Deficiency and Wound Healing: Experimental and Clinical Study, *Ann. Surg.* 105: 616, 1937.
15. Taffel, M., and Harvey, S. C.: Effect of Absolute and Partial Vitamin C Deficiency on Healing of Wounds, *Proc. Soc. Exper. Biol. & Med.* 38: 518, 1938.
16. Metheny, D.: Nutritional Deficiencies Complicating Surgery of the Gastrointestinal Tract, *Northwest Med.* 37: 319, 1938.
17. Lauber, H. J., and Rosenfeld, W.: Histologische Untersuchungen über das Verhalten des Vitamins C in den verschiedenen Organen während der Wundheilung, *Klin. Wchenschr.* 17: 1587, 1938.
18. Mason, M. L.: Wound Healing, *Internat. Abstr. Surg.* 69: 303, 1939.
19. Anderson, D. P., Jr.: Problem of Wound Healing: Effect of Local Antiseptic Agents on Infected Wounds, *Ann. Surg.* 108: 918, 1938.
20. Koster, H., and Kasman, L. P.: Relation of Serum Protein to Well Healed and to Disrupted Wounds, *Arch. Surg.* 45: 776, 1912.
21. Meleny, F. L.: Infection in Clean Operative Wounds; Nine-Year Study, *Surg., Gynec. & Obst.* 60: 264, 1935.
22. Ives, H. R., Jr., and Hirschfeld, J. W.: Bacterial Flora of Clean Surgical Wounds, *Ann. Surg.* 107: 607, 1938.
23. Howes, E. L., and Harvey, S. C.: The Strength of the Healing Wound in Relation to the Holding Strength of the Catgut Suture, *New England J. Med.* 200: 1285, 1929.
24. Colp, R.: Disruption of Abdominal Wounds, *Ann. Surg.* 99: 14, 1934.
25. Glasser, S. T.: Evisceration and Avulsion of Abdominal Wounds, *Am. J. Surg.* 32: 63, 1936.
26. Milbert, A. H.: A Study of Disruption of Abdominal Wounds, *Arch. Surg.* 31: 86, 1935.
27. White, W. C.: Disruption of Abdominal Wounds, *Ann. Surg.* 99: 34, 1934.
28. Grace, R. V.: Disruption of Abdominal Wounds, *Ann. Surg.* 99: 28, 1934.
29. Koster, H., and Kasman, L. P.: Wound Disruption, *Am. J. Surg.* 31: 537, 1936.
30. Maes, U., Boyce, F. F., and McFetridge, E. M.: Postoperative Evisceration, *Ann. Surg.* 100: 968, 1934.
31. Meleny, F. L., and Howes, E. L.: The Disruption of Abdominal Wounds With Protrusion of Viscera, *Ann. Surg.* 99: 5, 1934.
32. Kraissl, C. J.: Suture Material: Review of Recent Literature, *Internat. Abstr. Surg.* 62: 417, 1936, in *Surg., Gynec. & Obst.*, 1936.
33. Taylor, F. W.: Surgical Knots, *Ann. Surg.* 107: 458, 1938.  
Taylor, F. W.: Surgical Knots and Sutures, *SURGERY* 5: 498, 1939.
34. Ellis, J. D.: Rate of Healing of Electrosurgical Wounds as Expressed by Tensile Strength, *J. A. M. A.* 96: 16, 1931.
35. Magyary, G.: Ueber die Wundheilung nach elektrischen Operationen, *Arch. f. klin. Chir.* 169: 737, 1932.
36. Hauberrisser, E.: Zur Wundheilung bei Anwendung des Hochfrequenzschnittes. Unter besonderer Berücksichtigung der Mund-, Kiefer-, und Gesichtschirurgie, *Beitr. z. klin. Chir.* 153: 257, 1931.
37. Physick, P. S.: *Elect. Rep. & Anal. Rev.* 6: 389, 1816.
38. Porta, L.: Delle alterazioni patologiche delle arterie per la legatura e la torsione, esperienze ed osservazioni, Milan, 1864, p. 40.
39. Lister, J.: Observation on Ligatures of Arteries on the Antiseptic System, *Lancet* 1: 451, 1869.
40. Brewer, J. H.: The Present Status of Sterility of Catgut Sutures on the American Market, *J. A. M. A.* 108: 722, 1937.

W. B. Russ of San Antonio described the working of the OCD nonprofit blood bank for civilians, emphasizing its usefulness.

The Association's president, **Barney Brooks** of Nashville, in his presidential address, reviewed the development of surgery, calling attention to the importance of studying the patient from a psychic, as well as a somatic standpoint.

**Walter E. Dandy** of Baltimore discussed the newer aspects of ruptured intervertebral disks, stating that 98 per cent are diagnosable clinically without intraspinal media injections, and that nearly all can be cured by complete removal of the disk.

**Paul B. Magnuson** of Chicago discussed the differential diagnosis of causes of pain in the lower back accompanied by sciatic pain. In his opinion, backache with sciatic pain is not as simple a problem as it has been made to appear and requires careful differential study.

**Guy A. Caldwell** of New Orleans discussed the diagnosis and treatment of spondylolisthesis. He called attention to the fact that only 10 per cent of individuals with low back pain had spondylolisthesis. He described the mechanism of pain production and emphasized the importance of adequate x-ray visualization. Results following conservative and operative management were compared.

**Nathan Womack**, and (by invitation) **Heinz Haffner** of St. Louis indicated the significance of cholesterosis in badly damaged gall bladders, stating that in view of the irritating nature of cholesterol and bile salts, a chemical cholecystitis was demonstrable in one-third of the cases coming to surgery, indicating that inflammatory changes may be secondary to chemical irritation.

**R. S. Sanders** of Memphis studied 575 patients with gall bladder and common bile duct disease with especial reference to indications for surgery of the common duct.

**A. O. Singleton**, and (by invitation) **M. D. Knight** of Galveston reviewed the history and embryology of congenital tracheo-esophageal fistulas and reported the successful closure through a right-sided transpleural approach following gastrotomy.

**Harry Lee Archer** (by invitation), and **Edwin P. Lehman**, Charlottesville, Va., confirmed the observations of Firor and Poth in the clinical and laboratory use of succinylsulfathiazole. Thirty-six patients were given this drug in preparation for operations on the large bowel with benefit and notable freedom from systemic reactions.

**Joseph D. Collins**, Portsmouth, Va., presented a case of neurofibroma of the small intestine, calling attention to existing confusion in terminology and to the rarity of benign neoplasms in this location.

**William H. Prioleau**, Charleston, S. C., reported two cases of massive resection of the small intestine. Case 1, with volvulus, survived resection of 260 cm. of small intestine and 31 cm. of large bowel. Case 2, with volvulus, survived after removal of 354 cm. of small intestine and 40 cm. of large bowel, but died later following a recurrent obstruction.

**Curtice Rosser**, of Dallas, described the simple nonspecific penetrating ulcer of the cecum, emphasizing the difficulties of recognition and the importance of closure and drainage.

**Warren H. Cole**, and (by invitation) **Lewis J. Rossiter** of Chicago, in a discussion of chronic cystic mastitis, indicated classification into four major types:

first, adenofibrosis, second, parenchymatous hyperplasia, third, precancerous hyperplasia, fourth, cystic disease. In their series of seventy-six cases, malignant transformation occurred in none of type one, in 3 to 10 per cent of type two, 20 to 30 per cent in type three, and 2 to 4 per cent in type four.

Alfred Blalock, and (by invitation) Edwards A. Park of Baltimore presented the surgical treatment of experimental coarctation (atresia) of the aorta. Ten of forty-three dogs survived after section of the aorta with closure of the ends followed by anastomosis of the subclavian into the side of the aorta.

John J. Martin, and (by invitation) Merlo Scott, Rochester, N. Y., reported the successful ligation of the abdominal aorta for dissecting aneurysm of the left common iliac.

Rudolph Matas of New Orleans reported his personal experiences in the surgical treatment of aneurysms of the lower extremities, emphasizing the importance of collateral circulation and intrasaccular suture.

Mims Gage (Lt. Col., Medical Corps) discussed the simplicity of the Matas endo-aneurysmorrhaphy, calling attention to the importance of testing the collateral circulation and to developing it when necessary.

D. C. Elkin (Lt. Col., Medical Corps), and (by invitation) Barnes Woodhall (Major, Medical Corps), Atlanta, Ga., in discussing combined vessel and nerve war injuries, stressed the necessity for careful examination and called attention to the fact that vascular lesions may develop slowly.

Howard Mahorner of New Orleans discussed the control of pain in post-traumatic and other vascular disturbances, emphasizing the relief of vasospasm following sympathetic injection by the Lariche method.

H. J. Warthen, Jr. (Major, Medical Corps), Richmond, Va., discussed the treatment of burns complicated by fracture, with particular reference to compression dressings and skeletal traction.

John E. Cannady, Charleston, West Va., presented a report of the healing of wounds as influenced by sulfonamide therapy and the use of cotton thread sutures. The author indicates a preference for sulfathiazole crystals in small amounts and is convinced that cotton sutures are less irritating than catgut, silk, or nylon.

Cobb Pilcher of Nashville, in a discussion of the chemotherapy of intracranial infections, reported observations on the use of sulfonamides and of penicillin under various experimental conditions. He concluded that the sulfonamides were irritating and produced convulsions often and although helpful in meningitis were of no benefit for encapsulated infections or brain abscesses. The intrathecal use of penicillin was safe and beneficial.

F. A. Collier of Ann Arbor discussed chloride intoxication. He stated that because some individuals have subnormal chloride levels the administration of sodium chloride solutions must be carefully watched and toxic symptoms recognized clinically.

Charles G. Heyd of New York, in a description of voice disabilities following thyroid surgery, reported a variety of speech and breathing defects following injury to the recurrent laryngeal nerve or its divisions. Dr. Heyd reviewed the physiology and anatomy of the larynx and pointed out that 5 to 10 per cent of normal individuals have unilateral vocal cord paralysis.

J. Garland Sherrill, Louisville, Ky., discussed poliomyelitis and allied lesions of the cord and meninges.

K. H. Aynesworth, Waco, Texas, in a discussion of the McBurney incision in acute appendicitis, called attention to the lack of agreement in regard to the surgical approach to the appendix, stating that since in 20 per cent of cases the appendix is abnormally situated, preoperative efforts to detect abnormalities of location should influence surgeons in their approach. He emphasized clean cutting as against tearing of the abdominal wall.

Edgar Burns of New Orleans discussed the modern management of diverticula of the urinary bladder, calling attention to the importance of bladder neck obstruction and complete urologic investigation. Three patients with neoplasms in diverticula were presented.

Robert E. Cone of Galveston discussed the management of cryptorchidism, with particular reference to the usefulness of the Keetly-Torek operation. Classification of cryptorchids permits judicious application of treatment, hormonal or surgical. Because of the possibility of natural descent, observation with postponement of surgery until puberty or shortly thereafter was advocated.

Joseph A. Danna of New Orleans, in a report of interesting experiences with ether anesthesia, noted that in several instances surgical anesthesia lasted for varying periods (as much as one and one-half hours) after open-drop administration was stopped. The clinical applications of this phenomenon were discussed.

# Book Reviews

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**Urology in General Practice.** By Nels F. Ockerblud and Hjalmar E. Carlson. Pp. 383, with 97 illustrations. Chicago, 1943, Year-Book Publishers, Inc.

This is another textbook of urology in abbreviated form. Within its limitations of space it is, in a sense, excellent. The commoner ailments of the male urogenital system are well covered, and it contains so many practical suggestions concerning treatment, that students, practitioners, and urologists will find it worth-while reading.

On the other hand, it is pretty arbitrary in many respects, and does not encourage the uninitiated reader to form any opinions of his own, nor to look further for information. The authors have undertaken to perpetuate the legend that sudden emptying of the chronically distended bladder is dangerous. Their habit of recommending three tablets of somebody's proprietary remedy a day instead of using the more formal terminology and giving the dosage in some system of weights and measures, while concise, is not in line with the best current practice.

Many urologists of experience will dispute their statement that treatment with the high voltage x-ray is of no value in vesical neoplasms. Exceptions are at least numerous enough to make this a harmful remark in a book aimed at the general practitioner.

One cannot but wonder at the source of the authors' impression that all the results of castration in the 1890's for obstruction at the vesical neck were satisfactory, "the prostate returning to normal size in every instance." Is this sarcasm? If it were true, the operation could hardly have been abandoned so completely. The reviewer feels that a book on urology for the general practitioner should not only mention the urea splitting bacteria in stone formation, but should point out that they usually follow instrumentation by a physician, and particularly misuse of an indwelling catheter. One misses, also, any helpful suggestions on the treatment of the tabetic bladder.

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**Essentials of Proctology.** By Harry E. Bacon. Pp. 361, illustrations 168. Philadelphia, 1943, J. B. Lippincott Co. \$3.50.

This is a volume of 361 pages with a foreword by Dr. Curtice Rosser. The material is presented very clearly and the book contains an adequate number of very good illustrations.

An interesting feature of this volume is the very complete index of signs and symptoms which is found on the fly page. This feature adds much to the value of the book and could well be duplicated by other authors.

Dr. Bacon has devoted sufficient space in discussing the anatomy, embryology, and physiology of the anus and rectum without burdening the reader with too much detail. The author covers all of the ordinary types of anorectal pathology as well as the differential diagnosis of the related diseases. Emphasis, upon the more important types of perirectal abscesses and fistulas and their treatment, is well made.

An entire chapter is devoted to tuberculosis of the anorectal region. This serves its purpose well in demonstrating the differentiation between tuberculous ulceration, ulcerative colitis, amebic dysentery, and hyperplastic tuberculous stricture, and malignancy.

The chapter on hemorrhoids is covered very well and is well illustrated. The injection treatment of internal hemorrhoids is discussed quite completely and the author's method of the surgical removal of hemorrhoids is described graphically.

In dealing with malignant tumors of the rectum and sigmoid colon, the author has given preference to the one stage abdominoperineal procedure without colostomy as described by Babcock. The one stage procedure of Miles is also described.

Dr. Bacon is an authority on lymphogranuloma venereum and in the text has devoted considerable space to the discussion of this disease. One cannot read this chapter without being impressed with the fact that too often many cases of this disease are missed.

Altogether, this book is a comprehensive manual of anorectal disease and compares favorably with the author's previous book, *Anus, Rectum, Sigmoid Colon*. The text can be well recommended to interested readers.

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**The Hospital Care of the Surgical Patient.** By George Crile, Jr., and Franklin L. Shively, Jr., Cleveland Clinic, with a foreword by Evarts A. Graham. Pp. 184, with 21 illustrations. Springfield, Ill., 1943. Charles C Thomas, Publisher. \$2.50.

This little book was intended primarily as an aid to the beginning house officer, and in most respects it should serve admirably for this purpose. It describes in most practical fashion the relationship that should exist between interns and nurses, between interns and staff members of hospitals, and between interns and the patient.

It outlines in brief and clear fashion the procedures which the intern might be called upon to do. Most of these procedures are described in modern and generally accepted fashion, but a few are not. There is no material on the blood or plasma bank, and the method of drawing blood from donors is the old open one rather than one of the closed ones which have generally been found necessary to prevent contamination and allow preservation of blood for days or of plasma for longer periods. Hot water bottles and warm blankets are recommended for the treatment of shock, a practice now generally and properly abandoned. The use of indwelling nasal gastric tubes for several days before operation is blamed for a very high incidence of postoperative pulmonary complications, a conclusion not reached in many other clinics.

Despite the faults which have been listed, the majority of the procedures and the bulk of the discussion are accurate, concise, and easily readable. This book is a very helpful addition to the armamentarium of the intern.

---

**Surgery of Modern Warfare.** By sixty five contributors, Edited by Hamilton Bailey. Ed. 1. Pp. 899, with 828 illustrations, in two volumes. Baltimore, 1941, Williams & Wilkins Company. \$10.00.

These two volumes embrace the entire range of traumatic surgery. The various sections are written by men who have had firsthand experience in the management of the wounded. The volumes contain accounts relating to projectiles and their effects upon various tissues, the organization of first aid and emergency medical services, transportation of the wounded; shock, its causes and management; the localization of foreign bodies, the choice of anesthetic agent and satisfactory sections on all regional types of injury incident to warfare. Volume II concludes with an appendix of 50 pages containing up to the minute last available surgical reports from the various Allied sectors.

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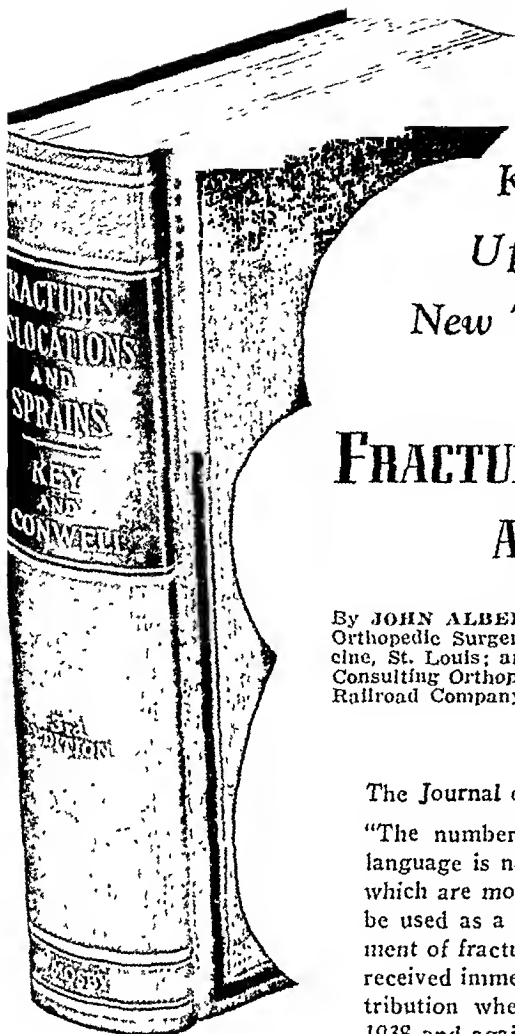
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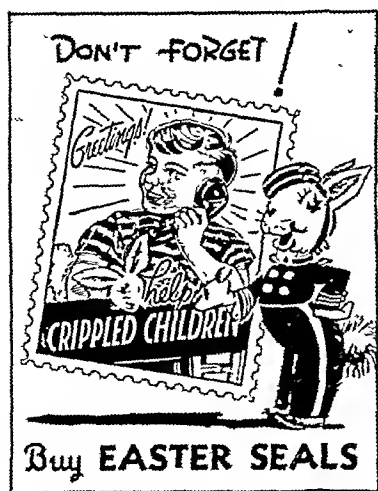
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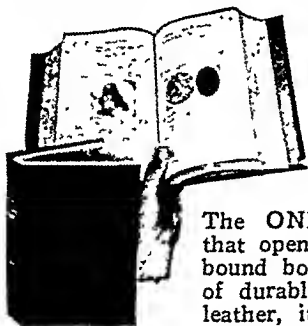
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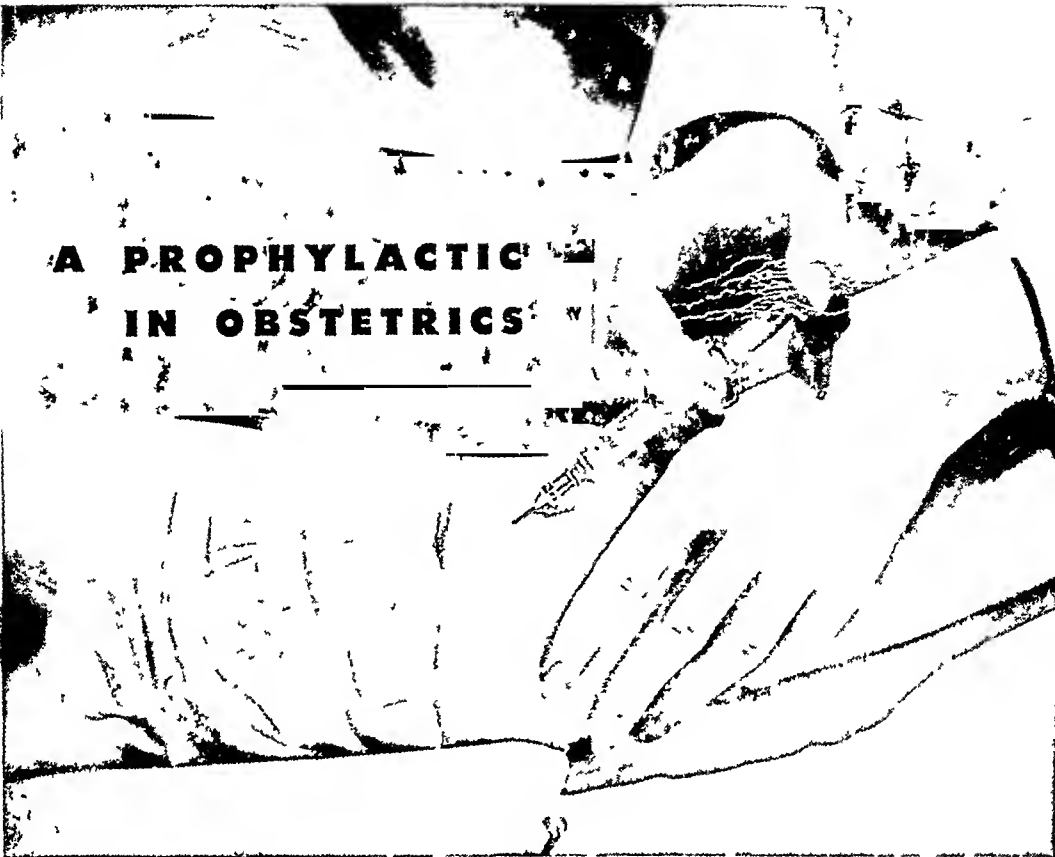
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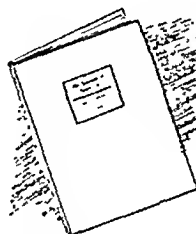
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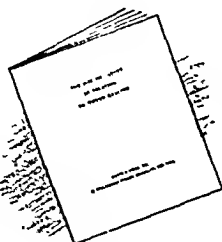
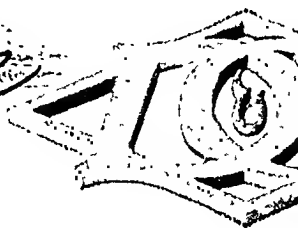
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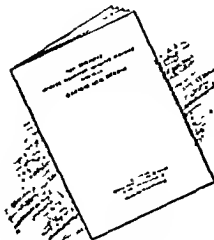


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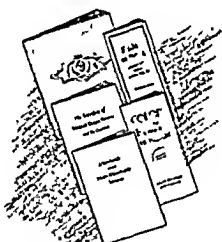
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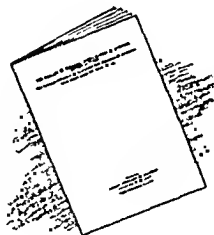
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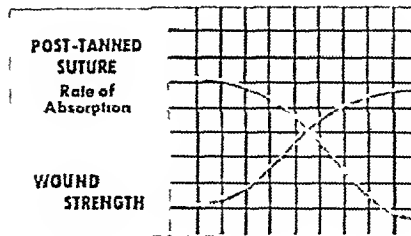
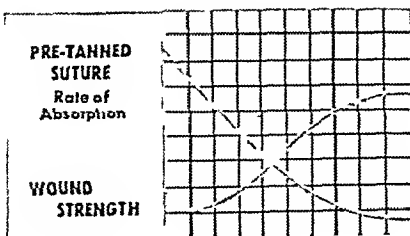


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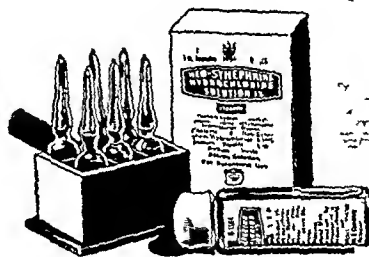
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so far I have learned of no other suggestion which provides the necessary valve which such an arrangement could give. It would be tragic if a lot of business concerns were wrecked and thrown into idleness because of inability to cut through the red tape in getting their claims settled.

#### POSSIBILITIES OF CONTRACTORS

In making these statements with reaction by the Federal authorities, I am also, that business concerns which contracts have a responsibility on it to facilitate speedy settlement of war contracts. They have the ability for preparing their claims accurately and speedily and presenting them in form. Some progress has been toward getting a recognition of the industry must play in this respect, and more and more experience of it is now being gained. The services of the Government, I know, very helpful attitude toward this situation the local office of W. P. B. has had a regional advisory service for war with problems resulting from termination. That is a very helpful point.

ation to make possible the prompt termination of war contracts is now. It will be unsafe to wait until a deluge of contract terminations to rough legislation on short notice. The problem is too complicated to be dealt with in that way.

#### MEASURES FOR CIVILIAN PRODUCTION

ation to making provision for the termination of war contracts, then the task of facilitating the flow of materials can be spared from war production. We shall not have enough here in Massachusetts because materials, which are physically in the United States, are unavailable by manufacturers as a result of legal or administrative restrictions. The legislation vesting the priority power in the President, which power the President delegated to the Chairman of the War Production Board, is probably adequate to the flow of materials, but it may be for the Congress to make sure that administration of the priority power by the War Production Board is directed effectively and speedily and that resumption of civilian production. The War Production Board should be expected to eliminate orders, the conservation and its allocation systems just as the needs of the war program per-

of their effects on plans for reconstruction. I foresee that these problems of canceled contracts and securing of raw materials for civilian production will presently be matters of wide concern here in Massachusetts. I summarize, my specific recommendation that legislation should be enacted the following points:

1. TERMINATION OF CONTRACTS. Terminated contracts should be set-aside by the contracting agency, Government, and the terminated contract should be final in the absence of misrepresentation.

2. PARTIAL PAYMENTS. Amounting to large percentage of the claim should be paid to each contractor upon a partial statement of the claim. No effect, so a penalty for perjury.

3. SETTLEMENT COMMITTEES. Should be authorized to authorize partial payments of over 30 days occurs on the Government agency.

4. Contracting agencies should be required to give prompt clearance of claims on work in process. There should be clear-cut procedures for authorizing the removal of Government-owned inventories and machines, with storage at Government expense, in order that civilian production may be started.

5. The dilemma of the subcontractors must be resolved. At the present time the Government exercises the right of approving all payments in settlement of subcontracts but does not assume any responsibility to the subcontractor, with the result that the subcontractor in many cases cannot secure action by either the prime contractor or the contracting agency. I suggest that the local settlement committees proposed above should be empowered to approve settlement of subcontracts if a delay occurs in approval by the contracting agency.

#### B. RECONTROL OF MATERIALS

1. As soon as war conditions permit, the rules for the release of raw materials should be revised with a view to facilitating the rapid resumption of civilian production.

### A Magnificent Job

#### EXTENSION OF REMARKS

OF

### HON. LOUIS LUDLOW

OF INDIANA

IN THE HOUSE OF REPRESENTATIVES

Tuesday, January 11, 1944

Mr. LUDLOW. Mr. Speaker, Indianapolis and Indiana are very proud of the great pharmaceutical house of Eli Lilly & Co., which has processed its millionth blood donation without a cent of profit. This record is in keeping with the fine, generous spirit which this firm always has manifested in the service of our country and which long ago brought to it the recognition of an Army-Navy E award. Commenting on the company's contribution to the blood campaign, which means so much in saving the lives of our precious boys, the Indianapolis News says editorially:

#### LILLY'S CONTRIBUTION

In the midst of charges that some concerns are making an unholy profit from war contracts it is heartening to learn that the Indianapolis laboratories of Eli Lilly & Co. have processed 1,000,000 blood donations entirely on a nonprofit basis.

In addition to performing this service at cost, the expense involved has been decreased constantly through the introduction of more efficient methods.

There certainly could have been nothing unethical if the Indianapolis pharmaceutical house had sought a minimum profit for the work it has been doing.

Donations of blood at Atlanta, Chicago, St. Louis, Detroit, Cincinnati, Louisville, Columbus and Indianapolis have been converted into life-saving plasma at the Lilly plant, involving the installation of new equipment and the employment of much additional skilled personnel.

The patriotic Americans who donated this blood, however, got nothing for their contributions and the Lilly Co. determined that its connection with the effort to strengthen the wounded on every fighting front should be entirely shorn of private gain. From beginning to end, it has been and is a magnificent job.

### The Gates Must Not Be Closed

#### EXTENSION OF REMARKS

OF

### HON. SAMUEL DICKSTEIN

OF NEW YORK

IN THE HOUSE OF REPRESENTATIVES

Tuesday, January 11, 1944

Mr. DICKSTEIN. Mr. Speaker, I leave to extend my remarks in order, I include the following editorial from the Daily Mirror of January 4:

#### THE GATES MUST NOT BE CLOSED

When Congress reconvenes on Jan. 11 it should take up the Gillette-Taft-Rogers resolution.

This resolution calls for the formation of a Presidential commission to create a new, in conjunction with the United Nations, to rescue the millions of Jews now being systematically exterminated by the Nazis and their quislings.

When the Presidential commission work, one of the first things it should seek the abrogation of the Chanin "White Paper" of May 1939.

At present, Palestine is being administered by Great Britain in conformity with a policy embodied in the "White Paper" of which Jewish immigration is limited and is to be stopped after March 31, 1944. This is now limited and is to be reduced to a permanent 10 percent in the country and the rest to Jews is to be practically prohibited.

#### A DIRECT REPUDIATION

This is a direct repudiation on the part of the League of Nations of the Balfour Declaration incorporated in the mandate of 1917.

According to this declaration, Palestine is to become a national Jewish home under the protection of England.

In 1922, after the Jews had created a national home in what was practically a desert, England turned on her solemn promise of 1917.

This repudiation of Britain toward the Jews was denounced by no one more than by Winston Churchill in Parliament the day on the "White Paper" when he said:

#### MR. CHURCHILL'S SECRET

"As one intimately and personally concerned in the earlier stages of our policy, I could not stand by and see engagements into which Britain has entered before the world set aside for reasons of administrative convenience or for the quiet life of the most acute manner myself by silence or inaction to what regard as an act of repudiation."

"I regret very much that the Balfour Declaration, endorsed as it is by successive governments, and the obligations under which we obtained that have both been violated by the Government's proposal."

"I select one point upon which plainly breach and repudiation of four Declaration—the provision that immigration can be stopped in 5 years by the decision of an Arab majority, a plain breach of a solemn obligation."

As the Palestine Mandate was given by the League of Nations, it cannot be altered by Great Britain herself without the consent of the League.

#### A SOLEMN OBLIGATION

But the League did not give its consent to the 1939 abrogation.



# SURGERY

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No. 3

## Original Communications

### ANTERIOR RESECTION FOR CARCINOMA LOW IN THE SIGMOID AND THE RECTOSIGMOID\*

CLAUDE F. DIXON, M.D.,† ROCHESTER, MINN.

*(From the Division of Surgery, Mayo Clinic)*

I HAVE always considered it a great opportunity to attend the meetings of the Chicago Surgical Society. On this occasion honoring Dr. Bevan I feel even more deeply concerning the privilege. Moreover, I am truly mindful of the responsibility the acceptance of your invitation entails.

Certainly it is not from lack of respect for the great surgeon in whose memory this lectureship was founded that I shall omit the biographic and eulogistic remarks that would be appropriate on this occasion. Rather, my omission springs from an excess of respect for him. I would not imply, by reviewing the life of one so recently deceased, that his years of achievement thus soon could have passed from the memory of his colleagues. Nor would I attempt to recount his accomplishments before an audience, many members of which witnessed the development of his projects day by day. I hope, then, you will agree that I can best honor Dr. Bevan by applying immediately what ability I have and what time is accorded me this evening to present one aspect of that immense field of surgery in which he spent his life and wrought so well.

My subject, anterior resection of the lower part of the sigmoid and of the rectosigmoid for carcinoma, cannot be and is not mentioned with the idea that the procedure is a new one. I have, however, during the past several years performed the operation I am about to describe in the hope that I could re-establish the continuity of the bowel and thus obviate the necessity of making a permanent colonic stoma.

Received for publication, Oct. 20, 1943.

\*The Bevan Lecture presented at a meeting of the Chicago Surgical Society, Chicago, Ill., Oct. 1, 1943.

†I wish to acknowledge the assistance of Drs. James L. Vadheim and R. E. Benson, Fellows in Surgery, of the Mayo Foundation, in the preparation of this lecture.

## TECHNIQUE OF ANTERIOR RESECTION

A low left rectus incision is employed. The liver and upper abdominal viscera are carefully examined by palpation in an effort to determine the presence or absence of distant metastasis. Next the tumor itself is examined and if it is removable the resection is begun.

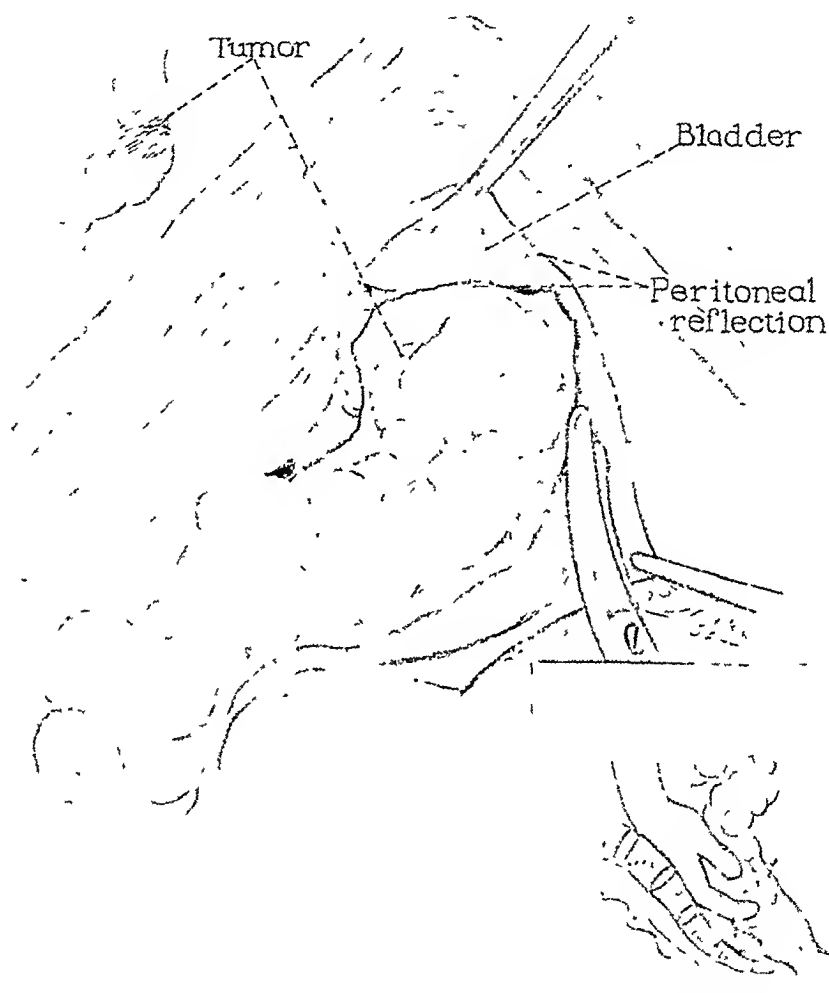


Fig 1—Situation of carcinoma to be removed by the technique described. The peritoneum is freed mesially and laterally as if a combined abdominoperineal operation were to be performed. Inset Method of mobilizing the pelvic colon, upper part of rectum, and adjacent tissues by passing the hand into the hollow of the sacrum. (From Dixon, C. F.: Courtesy of Paul D. Hoeber, Inc.)

The patient is placed in the Trendelenburg position. The peritoneum of the pelvic portion of the colon is first freed from the lateral aspect of the bowel and then from its mesial aspect. After that the ureters are identified and isolated. The peritoneum is divided between the base of the bladder and the rectosigmoid in a male, or across the posterior aspect of the cervix in a female (Fig. 1), as if an abdominoperineal resection

were contemplated. Next the lateral and mesial aspects of the mesocolon of the pelvic portion of the colon are incised; the incisions are begun at the level of the origin of the superior hemorrhoidal artery. Following this the superior hemorrhoidal artery and vein are ligated and divided (Figs. 2 and 3).<sup>2</sup> Care must be exercised to insure that the ligature is placed distal to the origin of at least one of the sigmoidal arteries which arise from the inferior mesenteric artery. Henceforth the blood supply

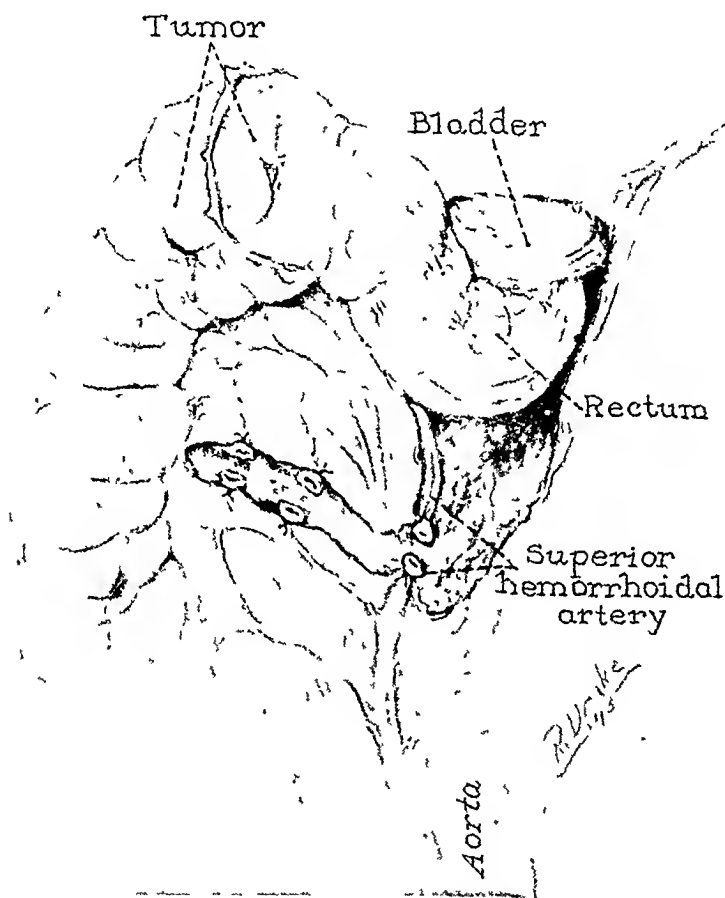


Fig. 2.—The superior hemorrhoidal artery has been ligated and mobilization of the lower pelvic part of the colon and upper portion of the rectum has been started

to the rectosigmoid or rectum will come from the middle and inferior hemorrhoidal vessels. The blood supply to the portion of bowel which is to be the proximal segment is from the inferior mesenteric vessels through the sigmoidal or marginal arteries

After the superior hemorrhoidal artery has been ligated and divided, the pelvic portion of the colon together with all of the adjacent tissue containing lymph nodes is mobilized by passing the hand into the hollow of the sacrum and lifting the structures as is shown in the inset in Fig. 1.

# SURGERY

Sup hemorrhoidal a  
removed with  
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and mesentery

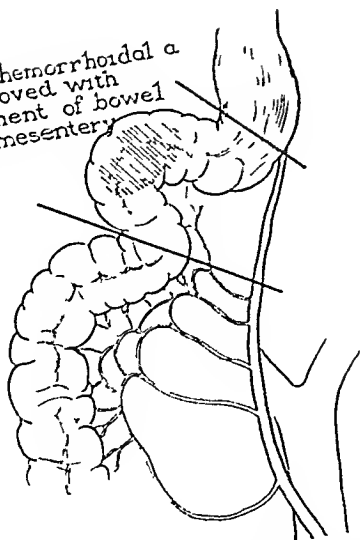


Fig 3—Ligation and division of the superior hemorrhoidal artery just distal to the point of emergence of the sigmoidal arteries and the segment of colon to be removed.

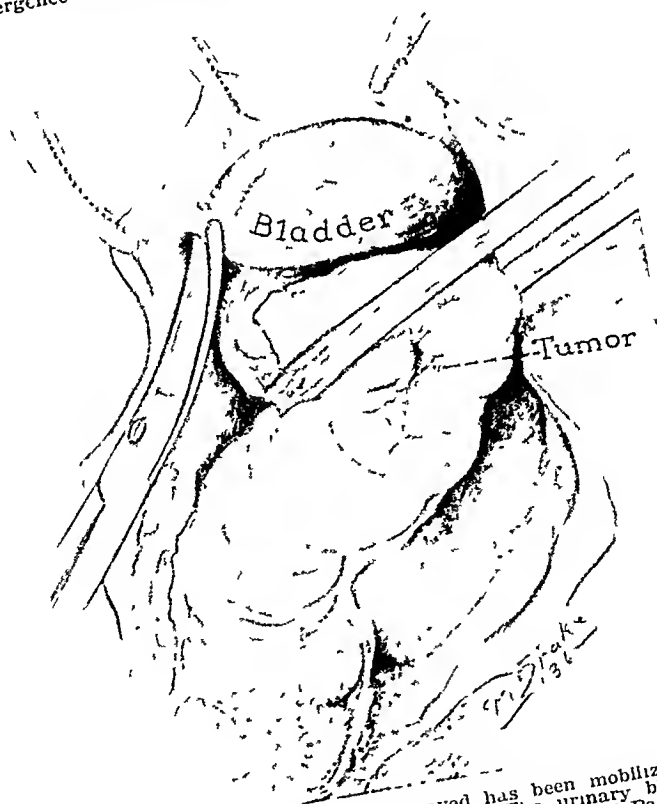


Fig. 4—The portion of colon to be removed has been mobilized posteriorly laterally and the ureter isolated and identified. The urinary bladder is dissected free and mobilized upward (From Dixon, C F, Courtesy of Paul B Hoeber

By this procedure the rectosigmoid can be mobilized and about one-half of the rectum can be drawn up into the pelvis (Fig. 4). The entire segment of colon to be removed is now mobile. Rubber-guarded clamps are applied (Fig. 5). The intestine is resected from the pelvic portion of the sigmoid flexure to the upper part of the rectum and an end-to-end anastomosis is made between the first portion of the sigmoid flexure of the colon, or the lower part of the descending segment, and the rectosig-

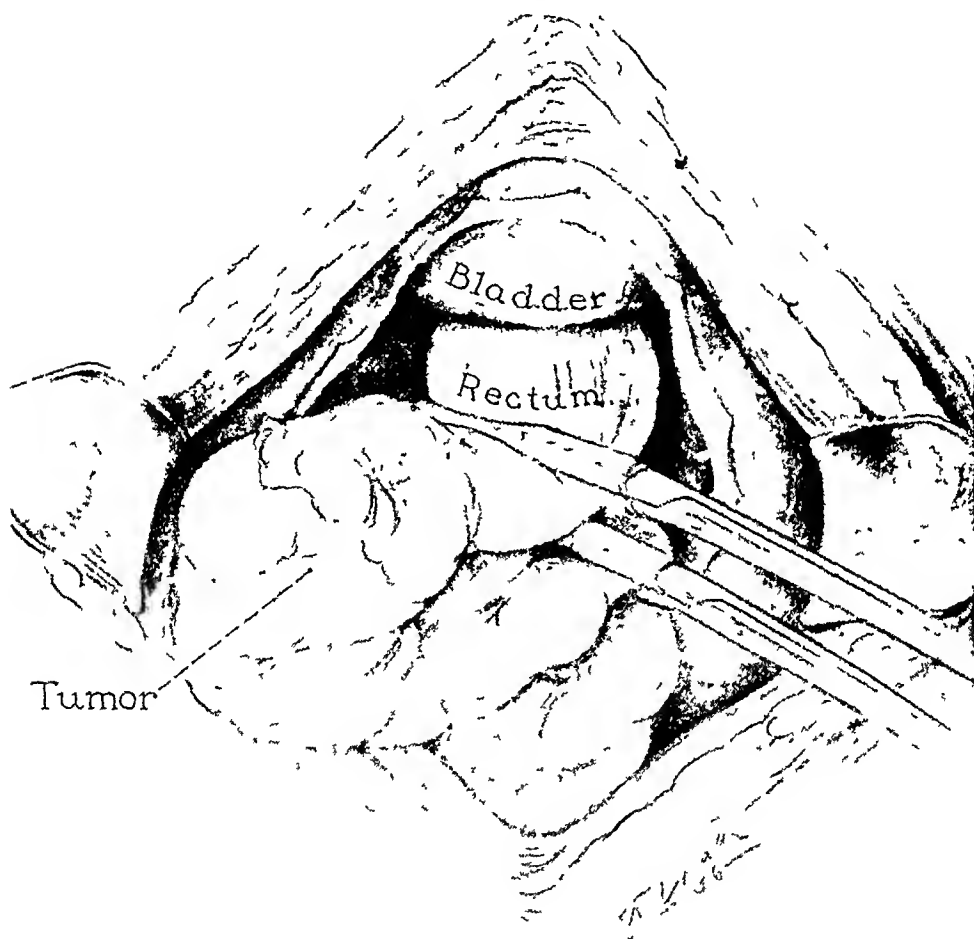


Fig 5—Rubber guarded clamps are placed at the points where amputation is to be made (From Dixon, C F<sup>2</sup> Courtesy of Paul B Hoeber, Inc)

moid or upper portion of the rectum (Fig 6). Often it is necessary to sever the outer peritoneal attachment of the descending colon as high as the splenic flexure for the purpose of mobilization. In some cases it is difficult to approximate the two ends of bowel owing to an abnormal shortness of the lowermost sigmoidal artery. Fig 7 illustrates how this technical difficulty can be overcome. By resecting the last sigmoidal artery and the small portion of the proximal end of bowel which is de-

pendent on it for its blood supply, the proximal and distal segments of bowel can often be brought into easy apposition

After the anastomosis has been completed, 5 Gm. (75 gr.) of crystalline sulfathiazole are placed in the hollow of the sacrum and around the site of the anastomosis. A Penrose cigarette drain is inserted into the hollow of the sacrum and is brought out through the lower end of the abdominal incision. The peritoneum is then replaced immediately above the line of suture. The peritoneal leaves are approximated by

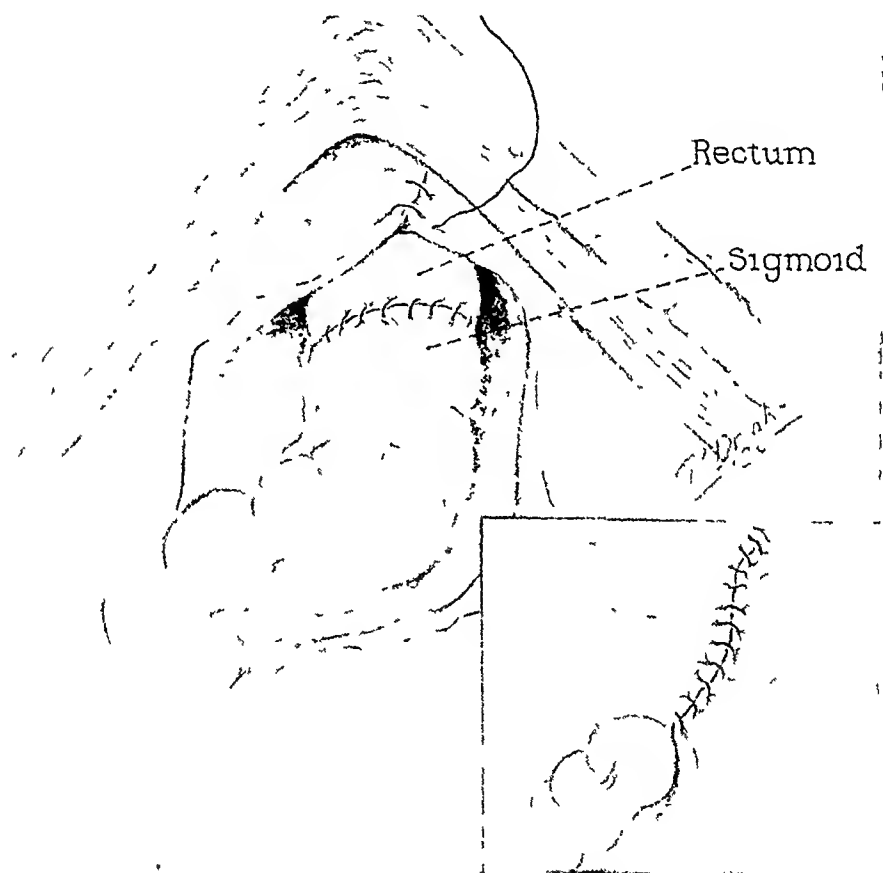


Fig 6—Completed anastomosis (end-to-end method) between the first portion of the sigmoid and upper part of the rectum. The pelvic peritoneum is approximated so that the anastomosis is extraperitoneal. (From Dixon, C. F.,<sup>2</sup> Courtesy of Paul B. Hoeber, Inc.)

suture to the lateral and mesial sides of the colon (which now occupy the pelvis) to form a reconstructed pelvic floor placed higher in the pelvis than normal.

Immediately after completing these procedures, a small upper midline abdominal incision is made, through which a knuckle of transverse colon is brought to the surface to permit a temporary colonic stoma to be provided. The primary incision then is closed in the usual manner and

also the secondary incision (usually only a few interrupted sutures of catgut are needed in the skin around the knuckle of bowel). Vaseline gauze is used for the purpose of sealing the upper abdominal incision around the knuckle of colon. Twenty-four hours later the portion of colon which was brought up into the midline incision is incised by means of the cautery. This colonic stoma may be closed three to six weeks later.

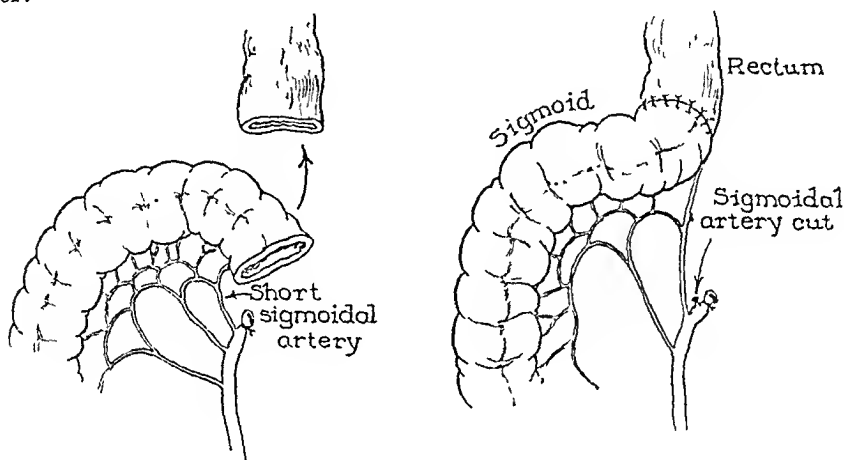


Fig. 7.—Method of overcoming difficulty in approximating the two ends of bowel due to abnormal shortness of the lowermost sigmoidal artery. The last sigmoidal artery and a small portion of the proximal end of bowel are resected thus allowing easy apposition of the two segments of intestine.

#### FACTORS OF IMPORTANCE TO ANTERIOR RESECTION

Formerly it was taught in some medical schools that ligation of the superior hemorrhoidal artery below the origin of the lowermost sigmoidal artery would compromise the blood supply of the rectosigmoid and upper part of the rectum so that necrosis of this portion of the bowel would result. The segment likely to become gangrenous was known as the critical point of Sudeck. It was reasoned that necrosis must occur because, it was believed, the marginal artery which courses parallel to the colon abruptly ends in the region of the lower sigmoid and does not anastomose with the blood supply from below. Logically, then, if the rectosigmoid depended on the marginal and superior hemorrhoidal arteries for its blood supply, and there could be no collateral circulation from below, this portion of the bowel would have to die. This may still appear to be true, but actually it is not. It can be definitely stated that the superior hemorrhoidal artery can be ligated and removed and even some of the marginal artery can be resected, as of necessity must be done in removing some of the lower left portion of the colon and the first portion of the sigmoid without significantly damaging the blood supply to the remaining portion of the descending colon, rectosigmoid or rectum. It is, in brief, safe to assume that all the colon which lies below the brim of the true pelvis will remain viable without the

marginal or superior hemorrhoidal arteries. The blood supply to this distal portion of bowel is adequately cared for in my experience by means of the middle and inferior hemorrhoidal arteries. I base this statement on experience in more than 200 anterior resections in which both the superior hemorrhoidal artery and a portion of the marginal artery were removed without any difficulty arising from inadequate blood supply to the distal segment of bowel.

*A second fact which is equally important* to the development of the technique of the operation must be mentioned. Simply stated, it is that carcinoma of the rectosigmoid and lower portion of the sigmoid does not ordinarily metastasize downward. Malignant lesions in this location almost invariably metastasize proximally to the mesenteric lymph nodes along the superior hemorrhoidal and inferior mesenteric arteries if spread of the disease occurs. This fact is as important as the first, for if such malignant lesions did metastasize to nodes below the growth it would be essential to good surgical treatment in all such cases to remove the rectum and perirectal glands and surrounding tissues. If such lesions do not metastasize downward, to remove the rectum for growths in the rectosigmoid and lower part of the sigmoid seems purposeless and adds unnecessary mutilation. Surgeons are indebted to Gilchrist and David, Collier, Kay, and MacIntyre and others for establishing this second basic fact.

Collier, Kay, and MacIntyre found in their studies no instance in which retrograde metastasis occurred to a significant level below the primary lesion. Grinnell concluded that downward lymphatic spread is exceedingly rare in operative specimens and only occurs by retrograde flow when the high nodes are blocked. Westhue stated in his report that in seventy-four cases he found only one instance of retrograde metastasis, and felt that this could be discarded as having no clinical significance. Gilchrist and David found retrograde metastasis to the level of 4 cm. below the primary lesion in two cases out of twenty-two. In both these instances, however, the lymph nodes above the growth in the bowel were completely blocked with carcinomatous cells. This, then, is the second fact, that carcinomas in the left lower portion of the colon do not tend to metastasize below the primary lesion to any significant extent.

#### RESECTABILITY

In the years, 1935 to 1941 inclusive, I operated on 243 persons who had malignant lesions in the rectosigmoid or low in the sigmoid. Of these, 200 (82 per cent) underwent a radical resection with the view to cure. On forty-three a simple exploration of the abdomen, some palliative procedure, or palliative resection was carried out. Of the 200 patients on whom resections of the colon with view to cure were performed anterior resections were employed in 120 and other types of radical



procedures, mostly exteriorization operations, in 80. I still use the exteriorization procedure whenever the lesion is high enough to make it possible. The resectability rate in my series for lesions in the rectosigmoid and low in the sigmoid, in general, then is 82 per cent.

## RESULTS

The series on which I shall present results consists of 206 consecutive cases in which anterior resection was performed by me for carcinoma of the rectosigmoid or lower part of sigmoid, from the years 1930 to 1942 inclusive. These 206 cases are divided into (1) 181 cases in which anterior resection was carried out with a view of cure and (2) twenty-five cases in which the operation of anterior resection was done as a palliative procedure (Table I). I shall give the statistical results based on the 181 cases in which the operation was done as a curative procedure first and I shall consider the palliative resections later.

TABLE I  
ANTERIOR RESECTION IN 206 CASES

ANTERIOR RESECTIONS	TOTAL CASES	PER CENT
With view to cure	181	87.9
Palliation only	25	12.1
Total	206	100.0

*Operative Mortality After Anterior Resection With View to Cure.*—Of 181 patients who underwent anterior resections with view to cure, twenty-two died during their stay in the hospital. A few of them died after closure of the colonic stoma, which is done in my cases as a secondary procedure. This gives an over-all hospital mortality, based on the total number of patients, of 12.1 per cent. During the years of 1930 to 1938, inclusive, in which I performed my first 100 anterior resections, there were eighteen hospital deaths, an operative mortality of 18 per cent. In the last eighty-one cases there have been four deaths (4.9 per cent). Over the course of the years the tendency has been for the hospital mortality to decrease (Table II). I believe that because of the advent of sulfonamides and other new chemotherapeutic agents I can now consistently perform this operation with a hospital mortality rate of less than 5 per cent.

TABLE II  
OPERATIVE MORTALITY

INCLUSIVE YEARS	TOTAL CASES	HOSPITAL DEATHS	
		NUMBER	PER CENT
1930-1934	23	4	17.4
1935-1936	36	7	19.4
1937-1938	46	3	17.4
1939-1940	35	2	5.7
1941-1942	41	1	2.4
Total	181	22	12.1

*Three-Year Survival Rates After Anterior Resections Performed With a View to Cure.*—One hundred and four patients who underwent anterior resection with a view to cure, prior to Jan. 1, 1940, survived the operation and left the hospital. Of this number 102 were traced. Sixty (58.8 per cent) of the 102 patients traced were alive at the end of three years. If I include all the cases in which anterior resection was performed with view to cure prior to Jan. 1, 1940, whether the patients died in the hospital or not, the three-year survival rate becomes 49.1 per cent, that is 60 of 122 patients survived for three years or longer. The survival rate varies markedly according to the extent of the lesion found at the time of operation. Twenty-two (81.5 per cent) of twenty-seven patients who had carcinoma of type A (Duke's classification), 54.3 per cent of the patients who had carcinoma of type B, and only 44.5 per cent of those who had carcinoma of type C were alive at the end of three years or longer (Table III).

TABLE III  
THREE-YEAR SURVIVAL RATES\*

DUKE'S CLASSIFICATION	PATIENTS WHO SURVIVED OPERATION†		PATIENTS WHO LIVED 3 OR MORE YEARS AFTER OPERATION	
	TOTAL	TRACED	NUMBER	PER CENT TRACED
A	27	27	22	81.5
B	46	46	25	54.3
C	31	29	13	44.8
Total	104	102	60	58.8

\*According to Duke's classification after anterior resection for malignant lesions of the rectosigmoid and lower part of the sigmoid colon.

†Inquiry as of Jan. 1, 1943. Included here are patients operated on three or more years prior to the time of inquiry, that is, 1939 or earlier. Hospital mortality is excluded in the calculation of survival rates.

I think it is only fair to note that of necessity these three-year survival rates are based on cases in which operations were performed prior to 1940. This means that all the cases in which I operated in the early years before I had the operation well standardized, and the operative, postoperative, and preoperative care well in hand are included in the present series. I think that the results are better in these cases at present. I know that the operative mortality has fallen rather markedly and I think that as the years have passed the tendency has been to perform more and more radical resections and that the survival rates have been improved thereby.

*Palliative Anterior Resections.*—Twenty-five out of 206 anterior resections were classified as palliative by virtue of the presence of metastatic lesions at the time of operation, which were irremovable and precluded the possibility of cure. Hepatic lesions which were characteristically malignant and of considerable size were the most common findings in this group. Cases in which the small nodules in the liver or masses did not feel absolutely characteristic of malignant lesions were not included in the group of cases of palliative resections. Implants in

the parietal or visceral peritoneum which were not removable were the second most important cause of palliative operations. Operations for carcinoma of the rectosigmoid and lower part of sigmoid which had infiltrated into surrounding structures such as the base of the bladder, uterus, ovaries, tubes, and so forth were not considered palliative if it was possible to remove all the grossly apparent carcinomatous tissues by resecting these organs along with the colon.

The operative mortality from these palliative resections is high. Eight out of twenty-five patients (32 per cent) died as a result of the operation. Of eighteen patients having operations on or before Jan. 1, 1940, none survived for three years. Several, however, lived for more than two years.

Before I began to perform palliative anterior resection in these cases, exploration or a palliative colostomy was the usual treatment. I do not know whether or not anterior resection is justified for this group, but I feel sure that all who survived the operation were more comfortable during their remaining days for having had this type of surgery performed.

#### COMMENT

The technique of radical anterior resection of the lower part of the sigmoid colon and rectosigmoid and re-establishment of continuity in the management of carcinoma low in the sigmoid or in the rectosigmoid which I have described has required time to perfect. Careful preoperative preparation has reduced the operative mortality rate from 19.4 to 2.4 per cent. During the twenty-four months prior to Jan. 1, 1943, such operations were carried out on forty-one patients with one death, or a 2.4 per cent mortality rate. This rate is figured on the basis of the number of patients and not on the number of operations performed on them.

My present opinion is that the results obtained following the procedure described compare favorably with those ensuing from other surgical methods employed in the radical removal of malignant lesions of the lower part of the sigmoid colon. The spread of carcinoma usually is upward. The superior hemorrhoidal vessels may be sacrificed without apparent impairment of the circulation to the rectosigmoid or rectum.

#### REFERENCES

1. Coller, F. A., Kay, E. B., and MacIntyre, R. S.: Regional Lymphatic Metastasis of Carcinoma of the Rectum, *SURGERY* 8: 294-311, 1940.
2. Dixon, C. F.: Resection Without Permanent Colostomy for Carcinoma of the Rectosigmoid and Lower Portion of the Pelvic Colon. In Pack, G. T., and Livingston, E. M.: *Treatment of Cancer and Allied Diseases*, vol. 2, New York, Paul B. Hoeber, Inc., 1940, pp. 1414-1421.
3. Gilchrist, R. K., and David, V. C.: Lymphatic Spread of Carcinoma of the Rectum, *Ann. Surg.* 108: 621-637, 1938.
4. Grinnell, R. S.: The Lymphatic and Venous Spread of Carcinoma of the Rectum, *Ann. Surg.* 116: 200-216, 1942.
5. Westhuc: Quoted by Colp, Ralph: Discussion. *Ann. Surg.* 108: 638-640, 1938.

## THE FIXATION OF SKIN GRAFTS BY THROMBIN- PLASMA ADHESION

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**A**MONG the many factors which influence the take of free skin grafts one of the most important is accurate and complete fixation. This is true since survival of the graft depends upon the rapidity with which circulation is established. If the graft moves on the surface to which it is applied or if complete contact of the graft with the recipient bed is not continuously maintained then vascularization cannot take place.

Since contact and fixation may be defeated by movement of the graft, movement of the recipient area, or accumulation of fluid under the graft, the method of free graft application as used at present is designed to prevent these untoward events.<sup>1</sup> Movement of the graft is prevented by careful suture of the graft to the peripheral epithelial edges of the recipient area. On the extremities movement of the bed is prevented by splinting. On constantly moving parts such as the chest, which cannot be splinted, an attempt is made to have the graft and bed move in unison by holding it in place with an inlay form. But that this is not entirely efficient is shown by the smaller percentage of successful takes on chest and face than on the extremities. An attempt to prevent accumulation of fluid under the graft is made. This is done by perforating the graft so that fluid may escape, and by snug well-fitted compression dressings. Although fairly efficient in preventing serum accumulation under the graft, such a dressing is difficult to apply on irregular surfaces. If applied too tightly, spotty necrosis of the graft may result. The dressing must be left in place for four to five days until the graft is securely adherent.

One great objection to the entire method of accurate suture and compression dressing is that it is time consuming and must be carried out with great attention to detail to insure successful takes.

It is evident that this problem of keeping the graft in close contact with the bed is fundamental when one considers the manner in which a graft at first obtains nutrition and subsequently grows on the surface to be covered. The graft has been detached from the body and although the epithelial cells die slowly, as is shown by the fact that a skin graft when protected from drying can be kept viable for two weeks and longer by refrigeration, still the entire process of skin transplantation is a

race between the cellular degeneration of the graft and the establishment of vascular connections with the bed.

It is generally believed that during the first twelve to twenty-four hours there is an osmotic flow of plasma into the graft. Goldman<sup>2</sup> believed that the graft receives its first nourishment from this influx of leucocytes and lymph which he called "The plasmatic circulation." Davis and Traut,<sup>3</sup> from their experiments, also concluded that there is a stage of plasmatic circulation which probably plays an important role in the survival of the transplant. They pointed out that all workers agree that there is a migration of leucocytes and a flow of lymph into the graft. The length of time this osmotic process of graft nutrition operates is probably variable but there is evidence that it is the only means of nutrition for probably the first twenty-four to forty-eight hours. Davis and Traut state that the first new blood vessels are found in the graft between forty-eight to sixty hours after transfer. Red blood cells have been found as early as thirty-six hours after transfer. In twenty-two to seventy-two hours there are early anastomoses of small blood vessels between the graft and the bed. During this period the graft shows a degenerative process as well as active proliferation of the various elements, which gains impetus between the sixth and eighth days. According to Davis and Traut the balance between degeneration and proliferation depends on the status of the circulation of the transplant. By the fifth day there is regeneration of the various elements of the graft. In their experiments the graft resumed normal appearance in between fourteen to twenty days.

From personal observation of skin grafts of various types it has seemed to us that the one great factor in the failure of transplanted skin to remain viable is incomplete or transient contact of the graft and bed. This is so outstanding that while one approaches the grafting of a smooth, firm, immobile surface such as the forehead with complete confidence, the application of a free skin graft to a moving, yielding, possibly irregular surface such as the lip is always attended with some apprehension as to the ultimate viability of the entire graft. Failure of contact may result even when the graft is carefully sutured to the periphery of the defect. This failure of contact is often spotty in character and may be due to local hematoma formation, local serum collection, or the stretching of the graft across a depressed spot in the bed. If the bed is firm and smooth, these losses are usually minimal or absent since an even pressure can be efficiently exerted by appropriate dressings. The complete loss of a free skin transplant is unusual in the hands of surgeons experienced in this type of surgery, but it is not uncommon for the inexperienced or occasional operator. This is true because the absolute necessity of complete fixation contact of the graft and bed is not appreciated.

Another common factor in the failure of take of free skin grafts is that the graft applied has too great thickness, or possibly too great an area, for the vascularity of the bed in question. When it is remembered that the balance of degeneration and proliferation in a graft is delicate at 4 or 5 days, it can be seen that too tardy vascularization will result in ascendancy of the degenerative process. Thus, a full-thickness graft will rarely if ever take on a granulating surface. Full-thickness grafts when applied to fresh surgically made beds have a higher percentage of take when the graft is from a thin area such as the eyelid, groin, or inner surface of the upper arm. It is also common experience that small full-thickness grafts have a much higher percentage of take than full-thickness grafts of large square area, since in the smaller graft the circulation established around the periphery is relatively of more importance. In general, the thinner the graft the higher percentage of success. It is rarely possible to transfer subcutaneous tissue with the skin, since the thickness is so great that vascularization does not readily or quickly occur.

In brief, the survival of a free skin transplant depends upon speedy vascularization. At present this is provided for by selection of thin grafts and the attempt to maintain uninterrupted contact of bed and graft by mechanical pressure.

Now, it is well known that if a small skin graft is placed on a granulating surface and can be protected from being dislodged, it will grow. In fact this was the original Reverdin contribution. Such a graft does become more or less adherent due to the drying of plasma which exudes from the granulating surface but is easily dislodged until invaded by capillaries.

On a fresh surface the situation is quite different. Here the normal process of healing occurs, leucocytes and red cells are extravasated, a fibrin meshwork is formed through the cellular material, and with the formation of the clot, serum is squeezed out. If the graft is merely placed on the surface, serum accumulates under it. The capillaries must grow through the fibrinous cellular clot and serum to reach the graft. This process of vascularization takes too long and the graft dies. It is probably this sequence of events which caused surgeons for a good many years to apply grafts only to granulating surfaces. When an attempt is made to prevent this normal healing process of clot formation by absolute hemostasis and hence keep the graft and bed in contact, then it is probable, since the cellular material is minimal, that little thrombin is liberated and hence fibrin formation small. Thus the graft does not become biologically adherent and must be held in contact by pressure until capillary invasion occurs. The capillaries use the fibrin meshwork as a scaffold along which the cells grow and if the scaffold is scanty, vascularization is retarded.

Ideally, it would seem that for vascularization of a graft to occur as speedily as possible it should be biologically adherent to the bed at once. Theoretically this adherence should be of such a nature that it corresponds to the stage of wound healing just as the cellular debris is removed, and only the fibrin scaffold remains over which the fibroblast carrying capillaries could grow at once.

With these thoughts in mind we attempted to produce a preparation that would cause a graft to adhere to its bed, furnish nutrition as early as possible, and afford an eschar to protect the surface. After following several leads on dogs, the simplest, most efficient and theoretically most ideal method seemed to be the precipitation of fibrin between bed and graft by the addition of thrombin to plasma.

There have been few attempts to solve this problem. Whipple<sup>5</sup> reported that he had seen cases in which, after a granulating surface was frosted with an ultramicroscopic form of sodium sulfadiazine, grafts stuck and took well. This was an attempt to control infection, which is another cause of graft loss on granulations. Sano<sup>4</sup> advocated the use of plasma and an extract of the cellular elements of the blood. This was an attempt to produce a biologic adherence of the graft. The plasma and cellular extract were prepared autogenously in each instance. Because of this the method was cumbersome and although its successful use has been reported, a simpler more widely usable method would be preferable.

Although only autogenous skin grafts take permanently, it seemed to us that since pooled plasma is used without reaction and since thrombin is probably a definite chemical compound, there was no necessity of these materials being autogenous, and such has been our experience. In our animal experiments, autogenous skin grafts were successfully applied on dogs using human plasma and rabbit thrombin as the source of fibrin fixation.

There is a considerable amount of facts known about the properties of thrombin. It was first prepared in 1933 by Mellanby.<sup>6</sup> He demonstrated some of its properties and among these noted that the time required to coagulate plasma is inversely proportional to the amount of thrombase added. Whatever quantity is used, practically all of the thrombase disappears after fibrin is formed. This is of importance since Lozner and co-workers<sup>7</sup> showed that parenteral administration of thrombin is very toxic and results in generalized thrombosis. This would seem to be less likely to occur from the application of thrombin to a wound surface.

It is nontoxic when used in ordinary amounts as a hemostatic agent. In this respect it is quite efficient. Seegers and associates<sup>8</sup> showed that 1 c.c. of a 1 per cent solution will clot 1 c.c. of blood in two seconds. One part of purified dry powdered rabbit thrombin to 60,000 parts of a 0.25 per cent citrated blood results in coagulation in three seconds.

Thrombin can be used as a powder on open wounds without toxic effects. It has recently been used as a hemostatic agent in brain surgery.<sup>10</sup>

It would appear from the evidence cited that the only toxic effect that could occur from the application of thrombin to a wound surface would be its accidental introduction in comparatively large amounts into an open vein. This has not been reported from its use as a hemostatic agent and would seem still less likely when used in conjunction with plasma due to its almost complete and immediate inactivation.

Purified thrombin does not contain fibrinolysin.<sup>7</sup> Hence, the precipitated fibrin forms a stable clot which remains long enough for our purposes when added to plasma. It is a carbohydrate containing protein. It is highly soluble in water and in 0.9 per cent sodium chloride solution. A low concentration of many of the salts does not cause the precipitation of thrombin. It can therefore be dissolved in normal saline solution and may be made into any desired concentration.

#### METHOD

Any type of free graft may be applied. Reverdin, Davis deep grafts, Thiersch, split-thickness, dermatome, or full-thickness skin grafts may be used. The selection of one or the other should depend upon the character and extent of the wound, the availability of skin, and the ultimate result desired.

If the recipient site is a granulating surface, no preparation is necessary other than the mechanical removal of crusts and dead epidermis at the periphery. If the site to be grafted is a fresh surgical wound, hemostasis is carefully carried out. In traumatic wounds, dead and devitalized tissue should be removed and the accepted principles of wound care followed.<sup>11</sup>

The bed to receive the graft is flushed with stock plasma. Excess is to be avoided, since as fibrin is formed the fluid portion of the plasma remains. The desired grafts are removed. They should not be placed in saline solution or washed in any way since this removes the small amount of natural cohesive agents present. (It has long been noted that grafts seem to adhere and take better if this detail is considered.<sup>12</sup>) The undersurface of the graft is wet with thrombin solution. The graft is quickly applied and adjusted into the desired position. It is lightly pressed in place and so maintained for a few seconds. The graft will rapidly adhere to the wound following its every contour. As fibrin forms, clear watery fluid is squeezed out. Some of this escapes from under the graft; some is undoubtedly trapped under the graft. However, as this fluid is essentially an electrolyte solution of physiologic concentration it is probably rapidly absorbed. We have not observed any ill effects from not making openings in the graft to allow its escape and thus far have not considered this necessary. It may be that the fluid is of value in the early nutrition of the transplant.



The graft becomes so firmly adherent within a few minutes that it will wrinkle and move as normal integument when surrounding parts are moved. In one instance where a split-thickness graft was used to cover a traumatic loss on the dorsum of the hand, the graft within a few minutes would glide over the underlying structures in normal fashion when the fingers were flexed and extended.

The graft becomes so firmly fixed that sutures, splinting, or retentive dressings are unnecessary. The grafted wound may be left open since a dry eschar at once forms around its edge. A light dressing may be applied merely to protect the area from the bedclothes; it is better dispensed with.

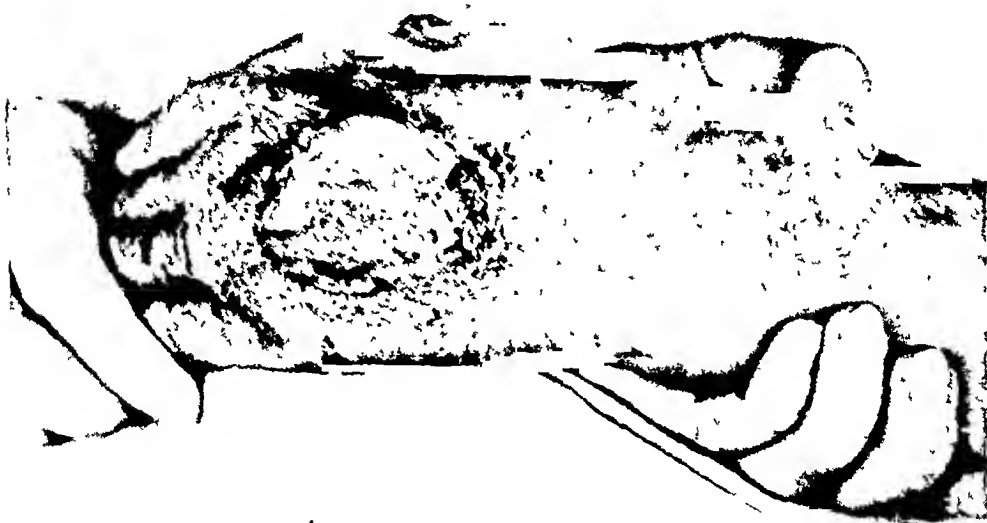


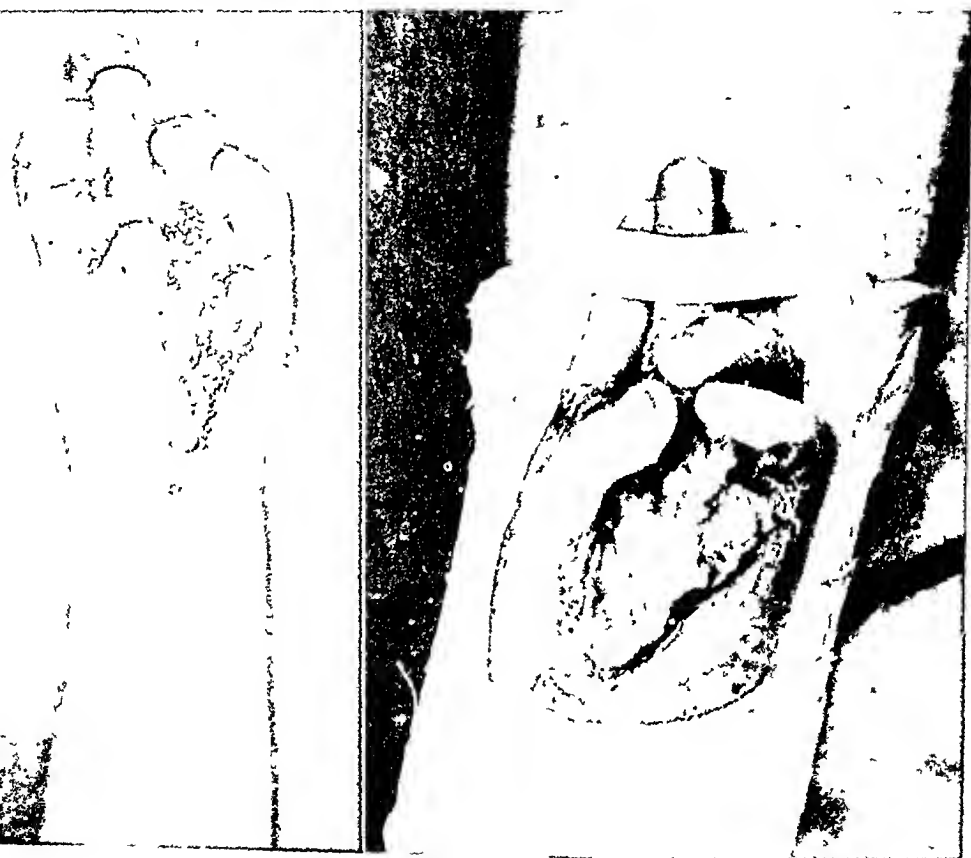
FIG. 1.—Dorsal skin of hand avulsed in winger exposing one extensor tendon. Split-thickness graft applied immediately after débridement; no sutures or compression. Graft securely adherent in thirty seconds after thrombin-plasma application. Wrist splinted because of senility and lack of cooperation. Photograph shows 100 per cent take on third postoperative day.

It would seem that the interlacing mesh of fibrin affords better nutrition for the graft. This may be due to either the presence of the fluid remains of the plasma, easier osmosis, or the more rapid ingrowth of capillaries.

That the graft becomes more quickly vascularized than as previously applied is quite striking. The graft surface remains normal in texture. Within twenty-four hours a split-thickness graft becomes pink and within forty-eight to seventy-two hours it will blanch on pressure and quickly recover its pink color, indicating an adequate circulation. We have not yet seen a split-thickness skin graft go through the intermedi-

ate cyanotic stage commonly observed at three to five days. This would indicate that the process of graft degeneration does not become ascendant and that the cells probably have their normal metabolism little disturbed.

The plasma we have used has been the stock pooled plasma from our plasma bank. This is prepared from a mixture of 50 c.c. of a 5 per cent sodium citrate solution and 500 c.c. of whole blood. As a matter of convenience we have packaged 5 c.c. of plasma in pyrex tubes sealed with



A.

B.

Fig 2—4, Granulating wound of palm of hand from wringer injury. All flexor tendons have sloughed and cartilage of two metacarpophalangeal joints is exposed. B, Plasma-thrombin adhesion, 100 per cent take of split-thickness graft applied without suture or compression. The graft lived over the areas of exposed cartilage which were about 1 cm square. Hand was splinted because the patient was a 4-year-old child.

rubber stoppers. A sufficient number of these are kept frozen in the plasma bank so that a considerable number are immediately available. These small amounts of plasma are all that are ordinarily required in applying a graft of considerable size. The small containers prevent waste and reduce cost. The tube is obtained and thawed by the operating room nurse as part of the regular equipment obtained for any skin

grafting procedure. Dried plasma may be kept in small vials ready for instant use.

Thrombin (prepared by Seeger's method)\* is prepared as a wafer sealed in a sterile glass ampule. These ampules are designated as 10,000 units. If 250 units are dissolved in 10 c.c. of saline, one part of the resulting solution of thrombin when added to four parts of plasma in a test tube produces a fibrin clot in thirty-five seconds. We divide the 10,000 units of powdered thrombin into ten parts and place each into a sterile vial. From this, dilutions are made as needed so that small glass tubes containing 250 units in 10 c.c. of solution can be kept on hand. These are kept in an ordinary refrigerator and will maintain their potency for one to two weeks. The strength of the solution can always be checked against a known amount of plasma and the time for clot to form noted. When thrombin is put on the market it would simplify its use for skin grafting and wound suture if it were put up in amounts of 250 to 500 units per ampule. The solution could then be made as needed without waste.

#### SUMMARY

The survival of free skin graft depends upon early vascularization. In order for this to occur the transplant must be held in complete continuous contact with the surface on which it is applied.

This can be accomplished by the precipitation of fibrin between graft and bed by adding thrombin to plasma. The rate of fibrin formation can be adjusted to any speed desired by increasing or decreasing the concentration of the thrombin solution.

This method has decided advantages. It takes little time as compared to the suture-compression dressing method. It seems to allow vascularization from three to four days earlier than former methods. It is practical, since plasma and thrombin can be stored in refrigerator and be ready for use at all times.

We believe a much higher percentage of take is obtained.

The precipitation of fibrin as a binding agent on wound surfaces would seem to have many obvious uses in surgery. At present we are investigating its usefulness in obliterating dead space between extensive raw surfaces such as result from radical mastectomy, as the sole suture material for lacerations of the face, and in the closure of subcutaneous tissues and skin in abdominal surgery. Its usefulness in these fields will be reported.

We wish to express our appreciation to Joseph W. Howland, M.D., for his valuable suggestions and criticisms concerning the preparation and use of thrombin.

#### REFERENCES

1. Byars, Louis T.: Free Full Thickness Skin Grafts, Surg., Gynec. & Obst. 75: 8-20, 1942.

\*Supplied to us for investigational purposes by Parke, Davis & Co.

2. Goldman, E. E.: Ueber das Schicksal der nach dem Verfahren Von Thiersch Verpfuntzen Hautstueckchen, Beitr. z. klin. Chir. 2: 229, 1893-94.
3. Davis, John Staige, and Traut, Herbert F.: Origin and Development of the Blood Supply of Whole Thickness Skin Grafts, Ann. Surg. 82: 871-879, 1925.
4. Sano, Machteld E.: A Coagulum Contact Method of Skin Grafting as Applied to Human Grafts, Surg., Gynec. & Obst. 77: 510-513, 1943.
5. Whipple, Allen O.: Basic Principles in the Treatment of Thermal Burns, Ann. Surg. 118: 187-192, 1943.
6. Mellanby, John: Thrombase: Its Preparation and Properties, Proc. Roy. Soc., London, s. B. 113: 93-106, 1933.
7. Seegers, W. H.: Purification of Prothrombin and Thrombin. Chemical Properties of Purified Preparations, J. Biol. Chem. 136: 103-111, 1940.
8. Seegers, W. H., Warner, E. D., Brinkhaus, K. M., and Smith, H. P.: The Use of Purified Thrombin as a Hemostatic Agent, Science 89: 66, 1939.
9. Lozner, E. L., MacDonald, H., Finland, M., and Taylor, H. L.: The Use of Rabbit Thrombin as a Local Hemostatic Agent, Am. J. M. Sc. 202: 593-598, 1941.
10. Putman, Tracy J.: The Use of Thrombin on Soluble Cellose in Neurosurgery, Ann. Surg. 118: 127-129, 1943.
11. Young, Forrest: The Care of Soft Tissue Injuries, New York State J. Med. 43: 1521-26, 1943.
12. Padgett, E. C.: Skin Grafting, Springfield, Ill., 1942, Charles C. Thomas, Publisher.

## NOTES ON THE DIAGNOSIS OF HERNIATED NUCLEUS PULPOSUS IN THE LOWER LUMBAR REGION

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**A**LTHOUGH accurate statistics will probably never be available, pain in the back is probably one of the most common human ailments. The problem is no less important in Army medicine than in civilian practice, for apparently backache is no respecter of age or of physical fitness. The soldier who is incapacitated with low back pain must be cared for in the Army if it is the result of military service. If there is a history of low back disability prior to induction, the soldier is generally returned to civil life without treatment. In any event, the problem of restoring these men to useful activities is a responsibility of the medical profession.

The purpose of this report is to discuss the role of the lumbar intervertebral discs in the larger problem of low back pain. We are fully aware that disc pathology is responsible for symptoms in only a small percentage of patients with lame backs, yet this lesion should always be considered in a differential diagnosis. Furthermore, the clinical manifestations of lumbar intervertebral disc lesions are, as a rule, sufficiently clear-cut that reasonably accurate diagnoses can be made in most cases on clinical findings alone.

### HISTORY

In almost every instance of traumatic lesions of the lumbar intervertebral discs, the first symptom is backache. Only about 40 per cent of the patients give an unequivocal history of trauma precipitating the first attack. The usual history is "when in a bent forward position, lifting a heavy object, a sudden catch is felt in the back and straightening upright can be accomplished only with excruciating pain." The outstanding characteristic of the back pain is its mechanical nature.

Some patients will fall to the ground with severe pain; in others the pain begins mildly and gradually increases until each movement of the back produces discomfort. Relief of pain is usually obtained by lying still in bed for an hour or more. Some patients state that comfort is obtained only in a sitting position and a few even learn to sleep in a chair. So long as the pain persists it is intensified by bending or lifting.

Illustrations and certain portions of text reproduced by courtesy of the Army Medical Bulletin.

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Strangely enough, some patients get relief from manipulation while others are relieved by complete immobilization.

Backache without radiation of pain into either leg is seldom caused by herniation of the nucleus pulposus. There is reason to believe that the lumbago associated with intervertebral disc lesions is caused by stimulation of the sensory nerve ending in the posterior annulus fibrosis and the posterior longitudinal ligament.

There may be one or more attacks of backache before the onset of sciatic pain. However, where trauma produces gross injury to the intervertebral disc, the leg pain may occur simultaneously with the low back disability. When the nucleus pulposus herniates through a tear in the annulus fibrosis, the intraspinal mass thus formed may impinge upon one or more components of the lumbosacral plexus with the production of sciatic pain. Pain is usually present along the entire course of the sciatic nerve. The points of maximum intensity are the gluteal region, the posterior thigh, and the lateral aspect of the leg or ankle. The gluteal region is the area to which the pain produced or intensified by coughing, straining, or sneezing is referred. Usually the sciatic pain remains unilateral but there are instances of bilateral pain, and not infrequently the pain will shift from one leg to the other during successive episodes.

Partial or complete remissions of symptoms occur characteristically in lumbar herniations of the nucleus pulposus. Recurrent attacks with freedom from pain between attacks is the usual history.

A patient with severe sciatic pain usually keeps the knee flexed; it is hard for him to get his heel to the floor. For this reason elevation of the heel of the shoe sometimes gives relief. Slight flexion of the knee and thigh gives relief of pain by relaxing the pull on the sciatic nerve. Any bending movement, sitting, or exercising exaggerates the pain.

Some patients report that certain parts of the leg are numb, or that certain parts of the leg or foot have a feeling of "needles and pins." An observing patient may describe his sensory involvement so accurately that a localizing diagnosis may be made. The pain is usually burning, stinging, or pricking and, in some instances, there is tingling and a feeling of electric shocks. For an accurate description of the dermatomes of the fifth lumbar and first and second sacral nerves, an anatomic textbook should be consulted. As a rough working basis it may be stated that the fifth lumbar dermatome is represented on the top and mesial side of the great toe and a small strip extending up the shinbone. The first sacral dermatome includes the dorsum of the foot, the four lateral toes, and a band about two inches wide extending up the lateral aspect of the leg to the knee. The second sacral dermatome extends posteriorly over the calf and the lateral aspect of the ankle and foot (Fig. 1).<sup>3</sup>

\*Drawings by Cornelia T. Thompson.

A herniated nucleus pulposus at the fourth lumbar interspace, i.e., between the fourth and fifth lumbar vertebrae, causes sensory disturbances primarily in the fifth lumbar dermatome. The same lesion at the lumbosacral disc (the fifth lumbar interspace) causes sensory disturbances in the first sacral and perhaps the second sacral dermatome. A large lesion at either level may involve one, two, or three dermatomes.

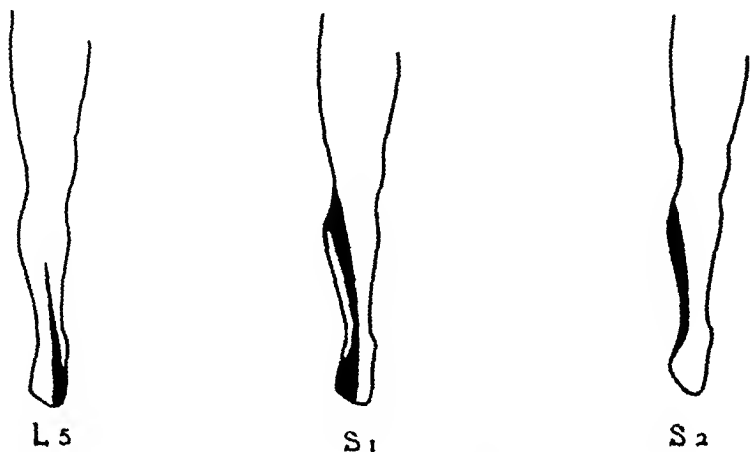


Fig. 1.—Approximate sensory distribution of L-5 (fifth lumbar), S-1 (first sacral), and S-2 (second sacral dermatomes).

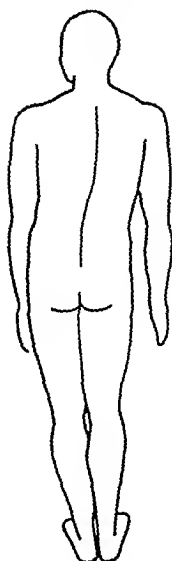


Fig. 2.

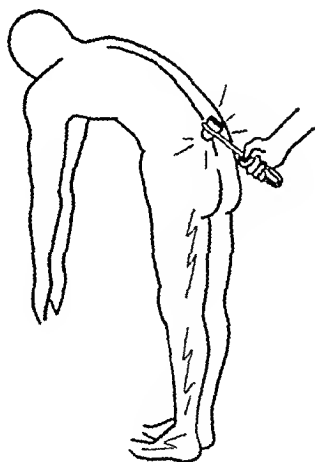


Fig. 3.

Fig. 2 —Typical list from lumbar disc lesion (left)

Fig. 3 —Production of radicular pain by deep percussion

No "low back" record is complete without a thorough general medical history, particularly with respect to symptoms of rheumatoid arthritis and acute or chronic systemic infections. A mimeographed "low back" form is a great convenience in recording the essential features of the history and physical examination. The one used at Walter Reed General Hospital is shown in Tables I and II.

TABLE I  
FRONT OF "LOW BACK" FORM

---

Register No. \_\_\_\_\_ WALTER REED GENERAL HOSPITAL Date \_\_\_\_\_

NAME \_\_\_\_\_ RANK \_\_\_\_\_ STATION \_\_\_\_\_

Line of Duty \_\_\_\_\_ Yes \_\_\_\_\_ No \_\_\_\_\_

Date of Onset \_\_\_\_\_ Trauma \_\_\_\_\_

HISTORY

Back Pain: Location \_\_\_\_\_

Duration (number of months) \_\_\_\_\_

Intensified by Bending \_\_\_\_\_ Lifting \_\_\_\_\_ Coughing \_\_\_\_\_ Straining \_\_\_\_\_

Relieved by Lying Down \_\_\_\_\_ Immobilization (Type) \_\_\_\_\_

Leg Pain: Onset (describe) \_\_\_\_\_

Pattern: Radiation to Hip \_\_\_\_\_ Knee \_\_\_\_\_ Calf \_\_\_\_\_ Foot \_\_\_\_\_

Intensified by Coughing \_\_\_\_\_ Straining \_\_\_\_\_ Bending \_\_\_\_\_ Sitting \_\_\_\_\_

Relieved by Lying Down \_\_\_\_\_ Flexing Thigh \_\_\_\_\_

Sensory Disturbances:

Numbness \_\_\_\_\_

Tingling \_\_\_\_\_

ADDITIONAL HISTORY: \_\_\_\_\_

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#### EXAMINATION

The examination should be made with the patient disrobed. Observations with respect to the posture, gait, general alignment of the legs with the trunk, position of the feet, and the motion of the small joints should be made. A careful evaluation of the patient as an individual (i.e., his general appearance, his mental attitude, and his overall personality) is of prime importance, particularly if operation is contemplated.

Most patients with a herniated nucleus pulposus have a straight lumbar spine with obliteration or reversal of the normal lumbar lordosis. Most of them, in addition, show listing away from the side of the sciatic pain (Fig. 2). In almost every instance the pelvis on the affected side is higher than on the unaffected side. Movements of the lumbar spine are usually limited, especially in flexion. Extension of the spine is often painful. The erector spinae muscles may be spastic and the spasm may be greatest on the side opposite the lesion. Light percussion or pressure at the level of the lesion will usually demonstrate an area of localized tenderness. Deeper percussion just to the side of this tender area may cause radiating pain into the gluteal region or leg (Fig. 3). Radiating percussion pains thus produced are caused probably by waves of force transmitted through the ligamentum flavum to the affected nerve roots



TABLE II  
BACK OF "LOW BACK" FORM

## EXAMINATION

Back: Lumbar Lordosis ----- Muscle Spasm -----  
List ----- Right ----- Left ----- Pelvic Tilt -----  
Percussion Tenderness -----  
Radiating Percussion Pain -----  
Lateral Bending Test: 1. Toward Painful Side -----  
                                2. Away from Painful Side -----  
Hyperextension Test -----  
Leg: Sensory Changes: Hypesthesia -----  
                                Paresthesias -----  
Motor changes: Weakness ----- Atrophy -----  
Reflexes Right ----- Right -----  
Knee Jerks: Ankle Jerks:  
Left ----- Left -----  
Right ----- °  
Straight Leg Raising Test: Lasègue Test -----  
Left ----- °  
Jugular Compression Test -----  
Length of Extremities (A.S.S.-Ankle): Right ----- Left -----

### X-RAY REPORT

### RECTAL EXAMINATION

## SEROLOGY

## CLINICAL DIAGNOSIS

at the site of the lesion. When positive, this sign is almost pathognomonic of a herniation of the nucleus pulposus.

Lateral bending is often restricted, particularly toward the painful side. Bending forcibly toward the painful side for thirty to sixty seconds usually intensifies the back pain and may reproduce the whole pattern of leg pain, even the sensory disturbances (Fig. 4A). Bending away from the painful side usually gives relief (Fig. 4B). Not infrequently a patient is observed who obtains relief by bending toward the painful side. Occasionally one is encountered who has alternating se-

liosis. A herniation of the nucleus pulposus protruding near the mid-line should be suspected in such cases.

In testing for sensory changes, the patient must be relaxed and fully cooperative. Two forms of stimuli are sufficient to demonstrate gross sensory involvement—light touch with the finger tips and painful sensation with pinprick. In mapping out areas of sensory loss it is desirable to compare the normal with the abnormal side. In many instances the only sign of sensory disturbance will be the patient's statement that the skin of the involved area feels thicker than normal. In questionable cases, testing with heat and cold will demonstrate sensory loss when other tests are equivocal.

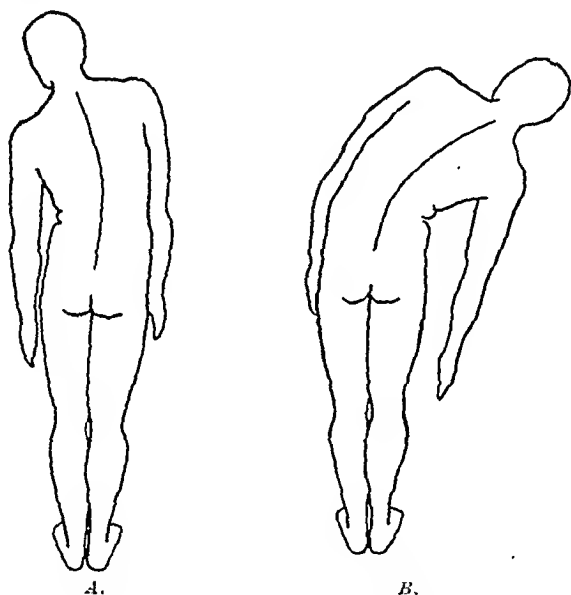


Fig. 4.—A, Restricted lateral bending toward painful side. B, Unrestricted lateral bending toward normal side.

Paresthesias may be described as peculiar sensations (electric shocks) spreading from the point of stimulation into the remainder of the involved dermatome. They are best reproduced by lightly stroking the skin with the finger tips.

Patients in great pain cannot exert maximum muscular effort. For this reason weakness of the gluteal and hamstring muscles is difficult to demonstrate. Some muscular weakness is probably present when the fourth or fifth and first or second sacral nerve roots are compressed to any degree by a herniated nucleus pulposus. The anterior tibial, the peroneal and the long digital extensor muscles are involved most frequently. Atrophy occurs both from disuse and from focal paralysis of nerves, particularly in cases of long standing. Fibrillation of the regional muscles occurs in certain cases. Gross paralysis or bladder dis-

turbances are rare and when they occur the lesion is more likely to be a neoplasm of the cauda equina.

Diminution or absence of the ankle jerk on the affected side occurs in at least 80 per cent of herniations at the lumbosacral disc, but in only 25 per cent of herniations at the fourth lumbar disc (Fig. 5). These changes in the ankle jerks, coupled with maximal sensory findings, are valuable in localization of the lesion. The knee jerks are seldom involved with herniations at the fourth or the fifth lumbar disc. However, with herniations at the third lumbar disc, diminution or absence of the knee jerk is to be expected due to involvement of the fourth lumbar nerve root.

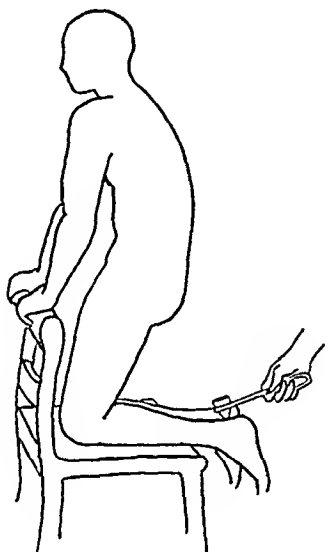


Fig. 5.—Recommended position for testing Achilles reflexes.

The straight leg-raising test is a valuable index of the degree of sciatic pain (Fig. 6). The angle at which pain appears may also be used as a reliable index for judging the progress of the case. The Lasègue's test is a useful refinement in equivocal cases (Fig. 7). These two tests are almost always positive in lumbar herniation of the nucleus pulposus producing sciatic pain.

Hyperextension of the lumbar spine usually greatly exaggerates the back and leg pain (Fig. 8). In this position, not only may the pain be exaggerated but the whole pattern of sensory disturbances in the leg may appear. When the *nonpainful thigh* is flexed upon the abdomen, relief of pain in the affected leg is experienced (Fig. 9). This test, when positive, is confirmatory evidence of a lumbar herniation of the nucleus pulposus.

The *jugular compression test* is performed by impeding the venous return from the internal and external jugular veins with digital com-

pression or with the cuff of a sphygmomanometer placed around the patient's neck. By increasing the intracranial pressure and consequently increasing the intraspinal pressure, the radicular pain in the affected leg is aggravated (Fig. 10). A positive jugular compression test is

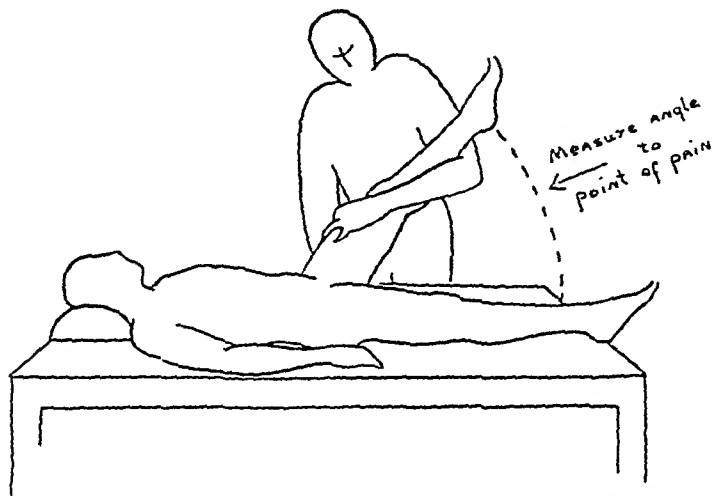


Fig. 6.—Recommended position for straight leg-raising test.

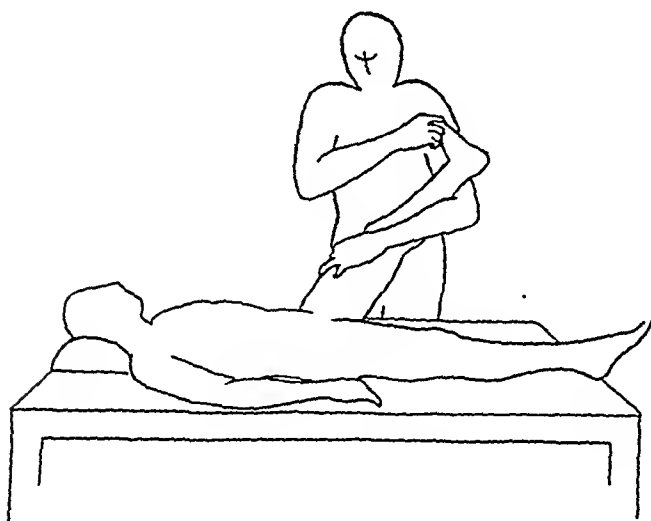


Fig. 7.—Lasègue's modification of straight leg-raising test.

pathognomonic of an intraspinal lesion, and when the pattern of the patient's leg pain is reproduced accurately the test is of great value in localizing the lesion.

#### LOCALIZATION OF THE LEVEL OF HERNIATION

Many lumbar herniations of the nucleus pulposus can be accurately localized on the basis of clinical findings alone. All cases have in com-

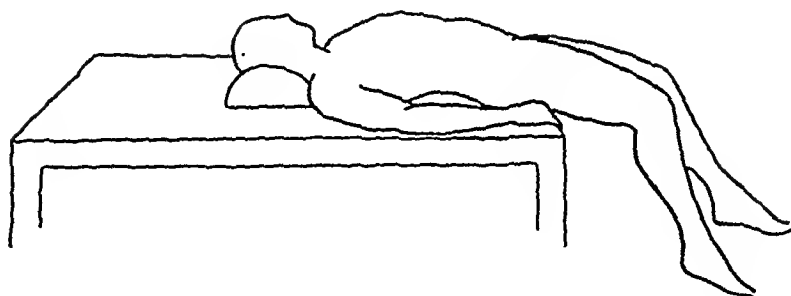


Fig. 8.—Recommended position for hyperextension test: extension of painful leg (left) restricted.

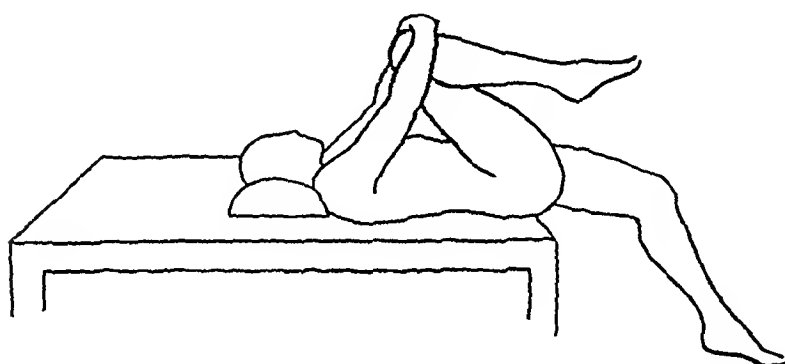


Fig. 9.—Hyperextension test: flexing normal thigh relieves painful leg.

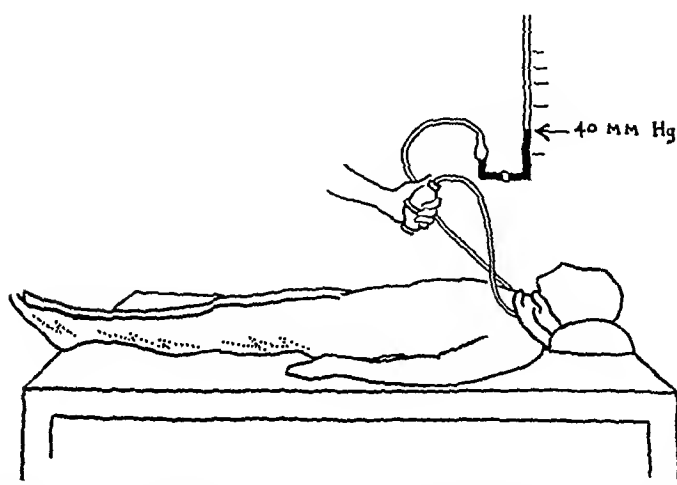


Fig. 10.—Recommended method for performing jugular compression test.

mon: (1) low back disability; and (2) pain in the distribution of the sciatic nerve.

The characteristic findings are as follows:

*Fourth Lumbar Interspace:*

1. Tenderness to percussion about the fourth spinous process.
2. Radiating pain on percussing to the side of the fourth spinous process.
3. Positive jugular compression test with tingling into the great toe (the fifth lumbar dermatome).
4. Knee and ankle jerks normal.
5. Hypesthesia and/or paresthesia in the fifth lumbar and the first sacral dermatomes.

*Fifth Lumbar Interspace:*

1. Tenderness to percussion about the fifth spinous process.
2. Radiating pain on percussing to the side of the fifth spinous process.
3. Positive jugular compression test with tingling into the top of the foot, sparing the great toe.
4. Diminished or absent ankle jerks; knee jerks normal.
5. Hypesthesia and/or paresthesia in the first sacral and the second sacral dermatomes.

#### DIFFERENTIAL DIAGNOSIS

If an injury initiates the symptoms of low back and sciatic pain, particularly if the injury has been a severe one, fracture of the spine or pelvis must be ruled out by appropriate x-ray study. If the symptoms develop insidiously, chronic conditions which affect the spine should be considered and ruled out. These include tuberculosis, low-grade osteomyelitis, Marie-Strümpell, rheumatoid and osteo-arthritis, myositis, fasciitis and congenital anomalies, especially spina bifida occulta and spondylolisthesis. Chronic or subacute abdominal conditions must be taken into consideration, although they rarely cause severe low back pain. Lesions in the prostate, particularly carcinomas, and metastatic tumors in the spine or pelvis from the breast, thyroid, lungs, prostate, kidney, and gastrointestinal tract must always be considered.

Differentiation between these lesions in the spine and pelvis is not, as a rule, difficult if the examination is carefully carried out in an orderly manner. However, in approaching the problem of low back disability, one frequently must exhaust his diagnostic acumen to arrive at a logical explanation for the pain, and not infrequently even the most careful study leaves the question unanswered. Appreciation of the fact that there is a definite clinical picture associated with rupture of the intervertebral disc and herniation of the nucleus pulposus will considerably reduce the number of cases formerly classified as low back pain of undetermined etiology.

## MYELOGRAPHY

Abundant clinical experience has indicated that in 60 per cent of lumbar herniations of the nucleus pulposus, the diagnosis can be established accurately upon clinical findings alone. The remaining 40 per cent can be demonstrated only by exploratory operation or by satisfactory myelography. While an exploratory operation may be a justifiable procedure, particularly if the operator is skilled in this type of surgery, one would prefer to use a simple and more precise method.

Myelography has, for the most part, been performed by three methods: (1) lipiodol; (2) thorotrast; or (3) air (or gases).

Lipiodol is in many respects a satisfactory medium for visualizing the spinal subarachnoid space. However, if the material is not removed, its telltale shadow persists more or less indefinitely. It can be removed, but the removal is attended with difficulties and at best is often incomplete.

Thorotrast gives excellent radiographic detail and interpretations can be made with great accuracy. Thorotrast can be removed completely by continuous spinal drainage. However, there are many objections to its use, not the least of which is the time-consuming procedure of continuous spinal drainage.

Air myelography is used more universally than any of the three because air is absorbed and leaves no demonstrable x-ray evidence of its use. The headache following this examination is often severe and incapacitating. The shadows cast by gases in the spinal subarachnoid space are, with highly refined radiographic technique, subject to fairly accurate interpretations. However, in many instances the radiographic diagnosis is presumptive and often equivocal.

A new myelographic medium is now available which combines the desirable qualities of lipiodol and thorotrast, and is more easily removed by aspiration. If a few drops are left, they are gradually absorbed. The material is Pantopaque and is the contribution of Dr. Stafford L. Warren, Professor of Roentgenology, University of Rochester (N. Y.) School of Medicine, and Dr. William Strain of the Eastman Kodak Company.

The technique of pantopaque myelography used at the Walter Reed General Hospital is as follows:

The patient is placed prone on the tilting fluoroscopic table with a small pillow beneath the abdomen. Lumbar puncture is done in this position, the needle being inserted distal to the fourth or the fifth lumbar spinous process. The puncture may be done below the third spinous process but at this level subsequent removal of the pantopaque is more difficult. Spinal puncture in the face-down position is as simple when one is accustomed to it as in the conventional position. One must be careful to keep in the midline and to insert the needle millimeter by millimeter after the ligamentum flavum is encountered. As soon as



Fig. 11.—Normal Pantopaque myelogram. Spinal needle shown at fifth lumbar interspace in *A*, *B*, and *D*. At *C* the pantopaque shadow hides the shadow of the needle. Note the smooth column with normally filling axillary pouches at the third lumbar (*A*), fourth lumbar (*B*), and fifth lumbar (*C*) interspaces. At *D* the opaque material has been aspirated after the myelographic study has been completed.

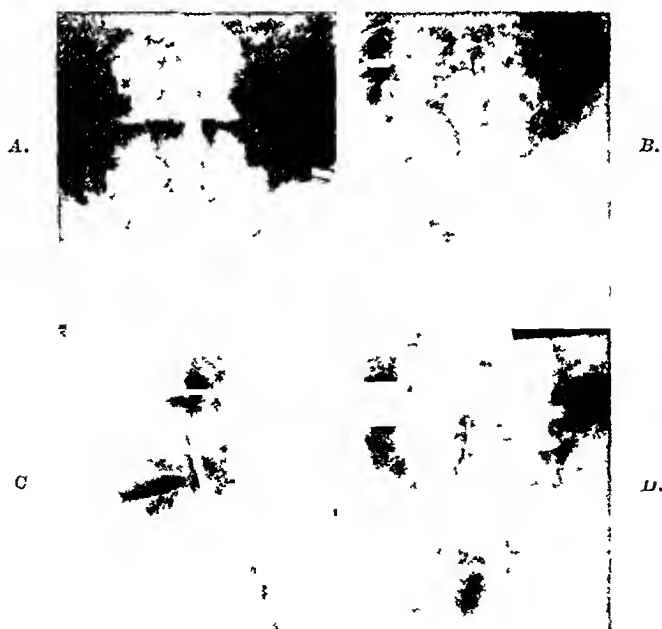


Fig. 12—Pantopaque myelogram of a large herniated nucleus pulposus at the fourth lumbar interspace. *A*, The large filling defect on the right, *B*, normal column and axillary pouches at the fifth lumbar interspace; *C*, lateral view showing characteristic anterior defect at the fourth lumbar interspace, *D*, complete removal of opaque material. Note the spinal needle at the fifth interspace in *A*, *C*, and *D*.



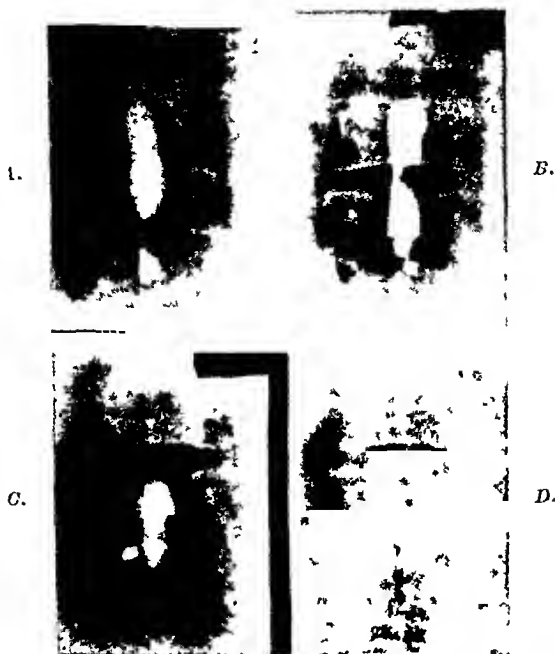


Fig. 13.—Pantopaque myelogram of a large herniated nucleus pulposus at the fourth lumbar interspace. *A*, Normal column and axillary pouches at the third lumbar interspace with defect beginning to form at the fourth lumbar interspace; *B*, characteristic defect at the fourth lumbar interspace left, with normal column at the fifth lumbar interspace; *C*, complete removal of drug.

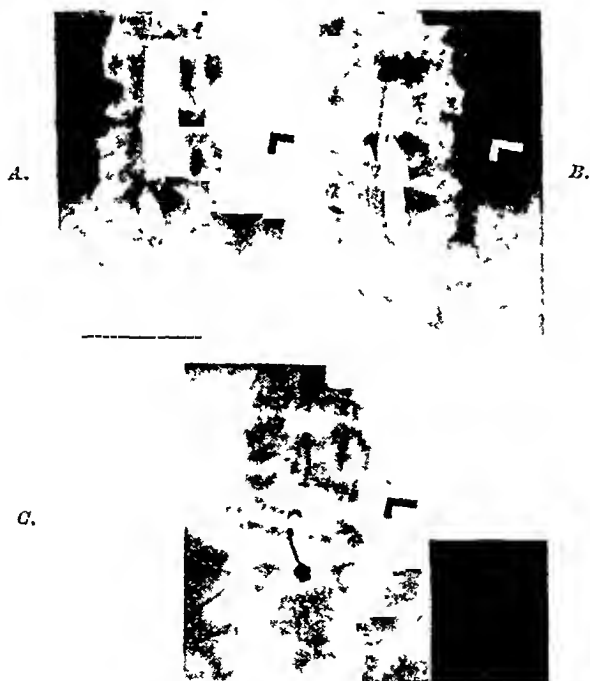


Fig. 14.—Pantopaque myelogram of a herniated nucleus pulposus at the fourth lumbar interspace on the left. *A*, Normal column and axillary pouches at the third lumbar interspace with defect beginning to form at the fourth lumbar interspace; *B*, characteristic defect at the fourth lumbar interspace left, with normal column at the fifth lumbar interspace; *C*, complete removal of drug.

# THE USE OF PHLEBOGRAPHY AND LUMBAR SYMPATHETIC BLOCK IN THE DIAGNOSIS OF VENOSPASM OF THE LOWER EXTREMITIES

## A PRELIMINARY REPORT

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IN RECENT years, investigators have made increasing use of phlebography in the diagnosis and treatment of thrombophlebitis and pulmonary embolism resulting therefrom.<sup>1-5</sup> Despite the accumulation of considerable experience with this method, there are still many controversial problems connected with its use. One of these problems has been the correct interpretation of filling defects in veins. Conceivably, these abnormalities may be due to partial or complete occlusion of the veins by thrombi, spasm of the veins, or a combination of both.

The attempt to differentiate these conditions is of practical and theoretical importance. Although there is disagreement as to the indications for femoral vein ligation in thrombophlebitis, both Fine and his co-workers<sup>5</sup> and Ochsner<sup>6</sup> agree that for certain types of thrombophlebitis, that is, the presence of suppuration of the veins and phlebothrombosis, ligation is indicated.

Members of the former group are more radical in their approach, maintaining that ligation is indicated in all cases of thrombophlebitis. Whatever stand one takes, the usefulness of phlebography as an aid in the diagnosis of the presence of a thrombus as opposed to venospasm alone cannot be denied. Further, as will be shown, the diagnosis of venospasm and the demonstration of the innervation of the deep veins of the lower extremity is an important concept in the pathologic physiology of the venous system. Fine<sup>5</sup> points out, "A reliable differentiation between the two processes (venospasm and thrombosis) awaits the development of an effective and simple technic to relax venospasm during roentgenography, so that the diagnosis of thrombophlebitis will be possible on the basis of structural filling defects only."

The material presented in this report demonstrates an "effective and simple technic" to differentiate venospasm from thrombosis, namely lumbar sympathetic block.

## METHODS

*Technique of Phlebography.*—All patients are interrogated concerning a history of allergic manifestations and also receive an oral sensitivity test for diodrast.

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The routine phlebograms are made by the slow injection of 25 c.c. of 35 per cent diodrast into any suitable vein on the foot, with the patient in the supine position. An anteroposterior roentgenogram of the leg is taken after the injection of from 15 to 20 c.c. of the contrast media. The leg is held in internal rotation in order to project the tibial veins into the interosseous space and the exposure is made on a 14 by 17 cassette with its upper border just above the knee. The roentgenogram of the thigh is taken immediately after completion of the injection (one minute). A soft rubber tourniquet, tight enough to obstruct the superficial venous circulation, is allowed to remain in place during the entire procedure. This technique will permit satisfactory visualization of all the deep venous channels. The superficial circulation is outlined by injecting the diodrast into the distal portion of the internal saphenous vein and omitting the use of the tourniquet. Not infrequently, from a single injection of the contrast media, both the superficial and deep veins will contain adequate density of media for interpretation.

If abnormal findings are present on the routine studies, phlebography is repeated to rule out technical errors such as inadequate concentration of media, and serial films of the involved area are taken.

There were no abnormal reactions to the injection of diodrast.

*Lumbar Sympathetic Block.*—This procedure is performed by the standard paravertebral approach. Toward the anterolateral surface of the second, third, and fourth lumbar vertebrae, 8 to 10 cm. needles are inserted from a point 5 cm. lateral to the midline of the caudal end of the corresponding spinous process. Injection of 10 c.c. of 1½ per cent metycaine in normal saline solution is performed in each area after the needle tip has just lost contact with the anterolateral surface of the vertebral body. In the absence of a constant temperature room, sympathetic denervation was considered adequate when the blocked extremity became obviously warm, pink, and dry and when the superficial veins of the foot became prominent. These conditions were fulfilled in all instances and appeared within fifteen minutes of completion of the block.

In the cases to be described, lumbar sympathetic block was performed within twenty-four hours of phlebographic study and phlebograms were repeated within the first hour after block.

CASE 1.—C. S., aged 32 years, a white soldier, was admitted to Torney General Hospital with the diagnosis of chronic cellulitis of the right leg with skin atrophy. The illness began in 1936, seven years prior to admission, when he suffered severe lacerations of the mid-portion of the right leg in an automobile accident. No fractures were sustained. Since the injury he has had pain and tingling in the affected leg on exertion and has had several episodes of skin ulceration at the site of injury.

Phlebography revealed a uniform constriction of the popliteal vein (Fig. 1) and the diagnosis of venospasm was made. Lumbar sympathetic block was performed and serial phlebograms were obtained beginning one-half hour after com-



Fig. 2.—Phlebogram made one hour following lumbar sympathectomy block shows a normal popliteal vein.



Fig. 1.—Uniform symmetrical narrowing of the right popliteal vein seen on original phlebographic studies.

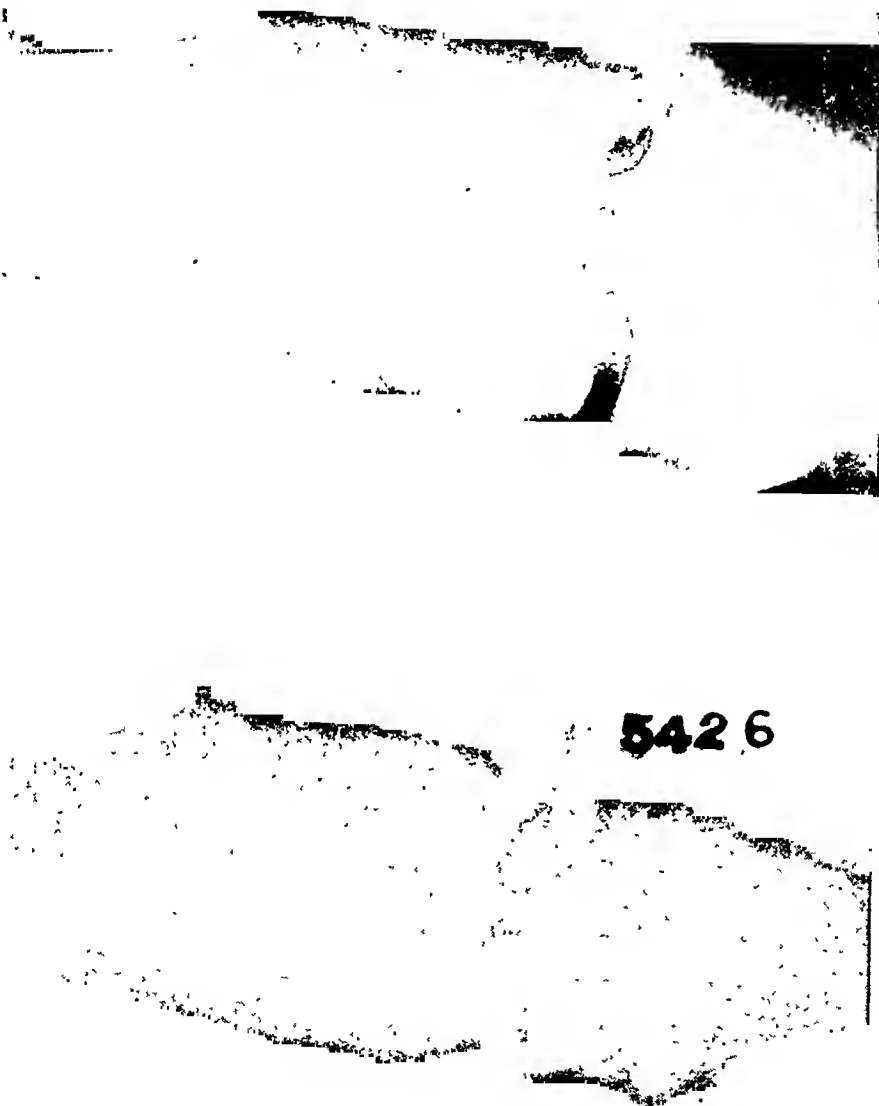


Fig. 3.—Constriction of right popliteal vein present on phlebographic studies made one week after initial block.

Fig. 4.—Studies made following a second lumbar sympathetic block again show a disappearance of the constriction of the right popliteal vein.

pletion of the block. Although the skin exhibited the characteristic evidence of sympathetic denervation, the initial film revealed no change in the diameter of the vein. However, there was progressive increase in the lumen of the vein until the end of the first hour post block when the vein was entirely normal (Fig. 2). This patient had pain relief for about five hours.

One week later these studies were repeated. The spasm of the popliteal vein was noted again and was again abolished by lumbar sympathetic block (Figs. 3 and 4).



Fig. 5—Original phlebographic studies of the left lower extremity were negative except for a uniform narrowing of the left external iliac vein.

CASE 2.—F. G., a white man, 33 years old, with two years and nine months military service, was admitted to Torney General Hospital complaining of difficulty in walking, swelling of both feet, pain in the calf muscles, especially the left, and dilatation of the veins of his legs, all of six months' duration. Past history revealed an inguinal herniorrhaphy of the left side, in 1940. Physical examination showed varicosities of the superficial veins of both extremities and an adequate deep circulation as judged by the Perthes test. The feet exhibited dependent cyanosis and blanching on elevation. The peripheral pulses in both feet were palpable. Laboratory studies including urine, blood, and spinal fluid were normal. On admission, thromboangiitis obliterans was suspected.

Phlebography revealed normal deep circulation bilaterally except for a moderate symmetrical constriction of the left external iliac vein (Fig. 5). The diagnosis of venospasm was made.

Lumbar sympathetic block was then performed on the left side followed by phlebography. There was a definite increase in the width of the external iliac vein (Fig. 6). It is interesting to note that this patient had excellent symptomatic relief for about eighteen hours.



Fig. 6.—Increase in width of the left external iliac vein following lumbar sympathetic block.

CASE 3.—H. W., a white soldier, aged 22 years, with three years military service, was admitted to Torney General Hospital with the diagnosis of chronic, recurrent, migratory phlebitis of the right great saphenous vein. The illness began with an injury to the right leg six months prior to admission to this hospital. Thrombophlebitis of the right great saphenous vein developed shortly after the injury. Ligation of the right great saphenous vein was performed at another hospital five months after the onset of the illness. Cure was not effected and the patient continued to suffer with recurrent saphenous thrombophlebitis and pain in the leg on exertion.

Six months following the original injury, and three days after admission to Torney General Hospital, phlebography revealed thrombosis of the deep femoral system with obstruction of the superficial femoral vein and thrombosis of the pro-



B

A.

Fig 7.—A, Original phlebographic studies of the right lower extremity showing obstruction of the superficial femoral vein and thrombosis of the profunda femoris. Note the filling defects in the profunda femoris. B, Normal popliteal and tibial veins as part of studies taken same time as A.





Fig. 9.—Increase in diameters of the popliteal and tibial veins but persistent filling defect on lateral wall of posterior tibial vein.



Fig. 8.—Uniform constriction of the right popliteal and anterior and posterior tibial veins (proximal portions) appearing five weeks after Fig. 7A and B.

funda femoris vein with partial recanalization (Fig. 7A). The popliteal and tibial veins were normal (Fig. 7B).

Phlebography was repeated five weeks after the first studies and demonstrated again, the defects noted. However, in addition, there was a uniform constriction of the distal end of the popliteal vein and the proximal portion of the anterior and posterior tibial veins, which was not present previously (Fig. 8). The diagnosis of venospasm was made, probably caused by the associated thrombophlebitis.

Lumbar sympathetic block was performed and phlebograms obtained. Following block, there was widening of the diameters of the distal end of the popliteal vein and the proximal ends of the anterior and posterior tibial veins, with a persistent filling defect on the lateral wall of the posterior tibial vein. The diagnosis of venospasm was substantiated and the concomitant presence of a thrombus in the posterior tibial vein was demonstrated (Fig. 9). This case demonstrates the co-existence of thrombosis and superimposed venospasm.

Clinically this patient had been improved. The weakness and pain in the leg disappeared following the single injection, and the patient remained free of symptoms for two weeks.

#### DISCUSSION

Examination of these cases and the radiographic demonstrations clarify some aspects of phlebography and the function of the deep veins of the extremities. However, there are new problems which remain to be answered. It will be noted that two cases of what is interpreted as venospasm and one case of thrombosis with superimposed venospasm are presented.

The first point that arises is the question of whether venospasm exists at all as a disease entity. Most comments on the problem of peripheral vascular tone discuss changes in the arterial or arteriolar tree alone either with no mention of venous tone<sup>2</sup> or lumping the entire problem in the use of the word vasospasm. Perhaps the only specific mention of venospasm is made by Ochsner and DeBakey<sup>7</sup> who have postulated that many of the signs and symptoms of thrombophlebitis are due to spasm of the arterial and venous systems with impulses originating from the diseased area. They have demonstrated conclusively with the use of lumbar sympathetic block that this reflex can be interrupted and that the release of arteriolar spasm is of distinct benefit.

However, it is felt that objective evidence of the possibility of venospasm of the deep veins has been lacking up to the present time. It is of interest to note that our cases support the postulates of these workers in two respects; first, that there is an entity of venospasm, and second, that thrombophlebitis may set up a reflex venospasm about the diseased area as shown in Case 3.

In searching for anatomic or physiologic evidence for the innervation of the deep veins of the lower extremities, little can be found in previous work. Best and Taylor<sup>8</sup> point out that veins receive constrictor fiber from the sympathetics. However, this statement includes only superficial veins of the limbs and no mention is made of the deep venous circulation. Davis<sup>9</sup> also mentions the innervation of veins by the sympathetics, but again there is no specific statement regarding the deep

venous circulation. A point of interest is the opinion that these fibers are given off segmentally in similar fashion to somatic nerves.

It is our thesis, on the basis of this preliminary work, that the deep veins of the lower extremity are innervated by the lumbar sympathetic outflow and that it is possible, as demonstrated in these cases, for excessive tone of this outflow to exist, resulting in spasm of the deep veins. Denervation of the veins by lumbar sympathetic block effectively removes this excess venous tone and allows the veins to dilate. These opinions are substantiated by phlebographie evidence.

There is an important criticism which may be levied against this concept. It is conceivable that dilatation of the veins observed may not be due to relaxation of spasm, but to passive distention by increased blood flow from the dilated arteriolar tree. This objection may be answered by the following argument. There is the probability that the dilatation of arterioles as a result of sympathetic denervation is a skin phenomenon, rather than a generalized one in the entire extremity. Further, the superficial veins are visibly dilated. It would seem apparent, then, that the preferential return of blood would be superficial rather than via the deep circulation. This argument could be settled definitely by direct measurement of the femoral arterial pressure by optical manometry and the rate and volume of blood flow emerging from the extremity. Unfortunately, equipment was not available for these determinations. It is hoped that these measurements will be made in the future.

Another factor mitigating against arteriolar overflow distending the affected vein, especially in the popliteal area, is the rich venous anastomosis in this region which should absorb readily any increased supply of blood resulting from arteriolar dilatation. Finally, it should be pointed out that arteriolar dilatation is evident at least fifteen minutes previous to venous dilatation, and frequently longer. If arteriolar overflow were the explanation, one should find evidence of distention of the veins almost at once, and such is not the case.

One question remains unanswered completely. It is not known from this work whether sympathetic innervation to the deep veins of the lower extremity is segmental or diffuse. It can be said with certainty, however, that the innervation is in the lumbar sympathetic chain.

There are many details which still await further study. More experience must be acquired as to the correct time interval for phlebography after nerve block, and until more information can be obtained, it seems advisable to obtain serial roentgenograms. Also, more emphasis should be placed on this disease to make the clinician more aware of its presence. Possibly, until more is known, painful extremities of obscure etiology might profitably be subjected to phlebographie study as well as suspected cases of thrombophlebitis.

The problem of therapy is another interesting matter for consideration. Our experience is too meager to do more than indicate possibil-

ities. It would seem rational to perform repeated lumbar sympathetic blocks at daily intervals in the manner suggested by Ochsner and DeBakey<sup>7</sup> for the treatment of thrombophlebitis. Possibly in this manner, the reflex arc would be abolished. Certainly, in this small experience, all the patients received dramatic relief of symptoms for varying periods of time. Phlebography should be done at intervals in the course of treatment to note any permanent change in the status of the venospasm.

Finally, a plea is made for more accurate definition of terms. We believe the term vasospasm should be discarded in favor of more accurate terminology. If the disease is arteriolar, it should be designated arteriolar spasm, and if in the veins, as venospasm. Perhaps in this fashion more information will be obtained concerning the separate parts of the circulation.

#### SUMMARY

1. Three case reports of venospasm of the deep veins of the lower extremity are presented.

2. The presence of a uniform symmetrical narrowing of a vein in the roentgenogram with adequate concentration of media is believed to be diagnostic of venospasm. This diagnosis is confirmed if the deformity is completely abolished by lumbar sympathetic block.

3. The concomitant presence of thrombosis and venospasm may be suggested only by comparing phlebographic studies before and after lumbar sympathetic block.

4. Evidence for the innervation of the deep veins of the lower extremity by the lumbar sympathetic nervous system is presented.

5. Suggestions for therapy of this disease are made.

#### REFERENCES

1. Dos Santos, J. C.: *Direct Venography; Conception, Technique, First Results*, J. Internat. de chir. 3: 625, 1938.
2. Bauer, Gunnar: *A Venographic Study of Thromboembolic Problems*, Acta chir. Scandinav. (Supp. 61) 84: 1-75, 1940.
3. Dougherty, John, and Homans, John: *Venography, A Clinical Study*, Surg., Gynec. & Obst. 71: 697, 1940.
4. Welch, Claude E., Faxon, Henry H., and McGaley, Claude E.: *The Application of Phlebography to the Therapy of Thrombosis and Embolism*, Surg. 12: 163-182, 1942.
5. Fine, Jacob, Frank, Howard A., and Starr, Arnold: *Recent Experiences With Thrombophlebitis of the Lower Extremity and Pulmonary Embolism. The Value of Venography as a Diagnostic Aid*, Ann. Surg. 116: 574-97, 1942.
6. Ochsner, Alton: *Discussion of*, Fine et al.<sup>5</sup>
7. Ochsner, Alton, and DeBakey, Michael: *Thrombophlebitis: The Role of Vasospasm in the Production of the Clinical Manifestations*, J. A. M. A. 114: 123, 1940.
8. Best, C. H., and Taylor, N. B.: *Physiological Basis of Medical Practice*, Ed. 3, Baltimore, 1943, Williams & Wilkins Company, p. 149.
9. Davis, L.: *The Principles of Neurological Surgery*, Ed. 2, Philadelphia, 1942, Lea & Febiger, p. 396.

## LESIONS OF THE BREAST

### THE RELATIONSHIP OF BENIGN LESIONS TO CARCINOMA

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THE relationship of benign lesions of the breast to the subsequent development of mammary carcinoma is important and on its understanding rests the rational treatment of a potentially malignant condition. Although it is generally accepted that benign tumors seldom give rise to malignant ones, the question arises, is the incidence of carcinoma higher in the breast which has given rise to a benign tumor than in the normal breast. This question is exceedingly difficult to answer, but by a follow-up study, the incidence of mammary carcinoma among patients who have had a previously proved benign lesion of the breast can be ascertained with reasonable certainty. Such a study was carried out at this time in an endeavor to further our knowledge of this problem.

Excellent collective reviews of this subject have been presented recently by Campbell,<sup>5</sup> Patey,<sup>13</sup> Warren,<sup>20</sup> Davis,<sup>9</sup> and others and an extensive review of the literature will not be undertaken at this time.

Many men have given thought to the relationship between benign and malignant lesions of the breast. Sir Astley Cooper<sup>8</sup> was apparently the first to realize that all tumors of the breast were not malignant. In 1835, he mentioned some of the distinguishing clinical characteristics of these two types of lesions. Since that time, numerous men have made significant contributions in this field. Brodie,<sup>4</sup> in 1844, mentioned that he considered cysts of the breast to be benign but that their presence did not eliminate the possibility of a coexisting cancer. Reclus<sup>16</sup> observed that cysts and other benign conditions of the breast were frequently multiple and bilateral. The contributions of Billroth,<sup>1</sup> Brissaud,<sup>3</sup> Schimmelbusch,<sup>17</sup> Virchow,<sup>10</sup> and König<sup>12</sup> were concerned with the pathogenesis of benign lesions of the breast. They endeavored to ascertain whether their cystic nature was due to a process of retention or to an inflammatory, neoplastic, or involutional process.

Many of the earlier investigators have reported series of cases in which carcinoma was found in breasts on which operations were performed for a benign condition. Evidence of this type has been interpreted by some to mean that the malignant lesions arose from the associated benign lesion. Schimmelbusch, in reviewing the literature in 1892, reported carcinoma found in three of forty-three cases of benign

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J cystic disease, an incidence of 7 per cent. Several other men have reported series of 9 to 115 cases of benign lesions. The incidence of carcinoma found by these men varied from 7 to 36.3 per cent and such results were presumed to indicate the frequency with which a benign tumor turned malignant.

Other investigators have examined the parts of breasts, amputated for carcinoma, which were distant from the malignancy itself. Cystic disease was found in these specimens with varying frequency by the different workers. Semb<sup>18</sup> found that cystic disease was associated with carcinoma of the breast in 77 per cent of a series of 122 cases. He found similar changes in only one of thirty-two routine post-mortem cases. Charteris,<sup>6</sup> in a similar study, examined in detail forty-eight breasts removed for carcinoma and found chronic cystic mastitis to be present in all but seven. He found cystic changes in only five of thirty-two breasts obtained at necropsy. Fraser<sup>10</sup> noted similar epithelial changes but, because they were particularly marked in a centrifugal fashion around the malignant lesion, considered them to be secondary to the carcinoma rather than precursory. Lewis and Geschickter,<sup>12</sup> on the other hand, found cystic disease in only 1.1 per cent of a series of 2,675 cases of carcinoma of the breast.

Some workers have approached the problem from a still different angle. They have followed groups of patients who had previously undergone biopsy or removal of benign lesions from the breasts. In most of the studies made on this problem in recent years, this approach has been used. Interestingly enough, the results of these recent investigators have been much more consistent and have revealed a lower incidence of carcinoma than those of the workers who used either of the other two methods mentioned. From a statistical point of view, it is by far the most satisfactory method of approaching this problem. The incidence of carcinoma as reported by various workers varies from 0 to 4.8 per cent.

Warren, in an excellent follow-up study of 1,206 cases of benign disease of the breast, showed not only the incidence of carcinoma developing in this type of breast, but also compared this incidence with the attack rate of cancer of the breast in the general population. He showed that the cancer attack rate for the entire group of women having had chronic cystic mastitis or related lesions is four and one-half times as great as it is for the Massachusetts female population:

From the histologic approach have come reports that indicate a definite relationship between chronic cystic mastitis and carcinoma of the breast. The monograph of Cheate and Cutler<sup>7</sup> is one of the outstanding contributions on this subject. They asserted that approximately 20 per cent of mammary carcinomas definitely began in cystiferous lesions. They also stated that the entire sequence of changes may be traced histologically from desquamative epithelial hyperplasia through

cyst formation, benign epithelial hyperplasia, to carcinoma. It is their belief that such a transition requires thirty years for its completion. Handley,<sup>11</sup> from a histologic approach, arrived at the conclusion that chronic mastitis is a precancerous condition and both mastitis and carcinoma have a common pathologic feature in lymphatic obstruction. Bloodgood,<sup>2</sup> on the other hand, stated that in 222 cases of chronic cystic mastitis in which simple mastectomy was performed, carcinoma could not be demonstrated in a single case.

#### CASES STUDIED AND RESULTS

In the present study, all the cases in which a benign condition of the breast was treated surgically at the Mayo Clinic during the years 1935 and 1936 were reviewed. The most common operative procedure used was local excision of the tumor. In some instances unilateral mastectomy and occasionally bilateral mastectomy had been done.



Fig. 1.—Chronic cystic mastitis, showing multiple cystic formations.

The entire group consisted of 540 patients. The pathologic nature of their lesions was classified into the following groups: chronic cystic mastitis; chronic mastitis; fibroadenoma; comedomastitis, and miscellaneous conditions. In the last group were included the lesions which did not present any marked pathologic abnormality.\*

The majority of the patients in our series had chronic cystic mastitis (Fig. 1). This term is used to include all the cystic forms of mastitis

\*We wish, at this time, to express our appreciation to Dr. J. R. McDonald of the Division of Surgical Pathology and Mr. Robert Gage of the Section on Biometrics for their helpful suggestions and criticisms.

(simple cysts, multiple cysts, and Schimmelbusch's hyperplasia). Grossly the breasts were nodular. Histologically, the nodules consisted of varying amounts of adenomatous tissue undergoing cystic formation. The group of cases classified as chronic mastitis (Fig. 2) referred to those lesions in which fibrous tissue or fat between the glandular tissue of the breast increased with a minimal amount of cyst formation.

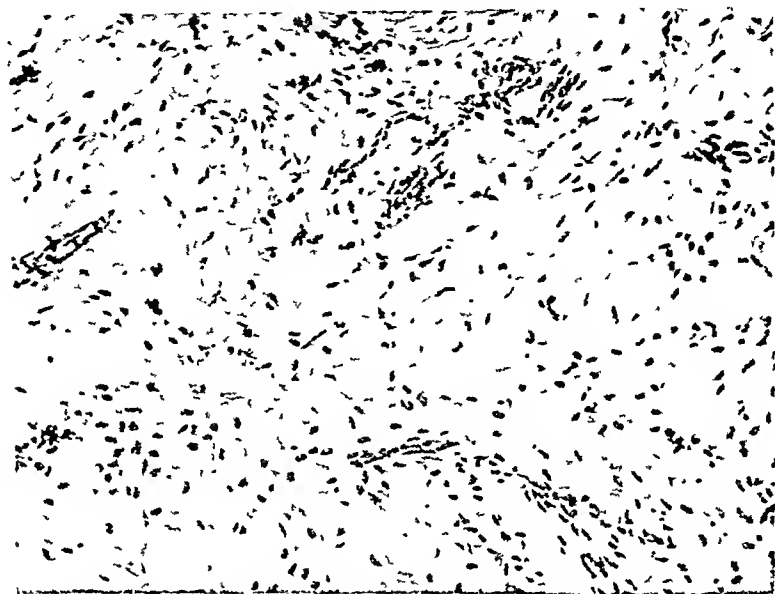


Fig. 2.—Chronic mastitis, revealing marked increase of fibrous tissue.

The term fibroadenoma (Fig. 3) was confined to those lesions in which a well-encapsulated tumor was removed and the glandular tissue was arranged in lobules; a varying amount of fibrous stroma was present. A small group of lesions was identified under the term comedomastitis (Fig. 4). A gross characteristic of these lesions was the debris which could be squeezed from the cut surface of the ducts when pressure was applied. Microscopically the ducts had thick fibrous walls and were filled with a relatively noncellular, homogeneous material. This type was associated, in some instances, with one of the other pathologic varieties.

The majority of the patients in the entire group were less than 50 years of age; approximately 25 per cent had passed the menopause.

The follow-up study was confined to 442 cases, thus eliminating sixty-eight cases in which bilateral simple mastectomy had been performed and thirty cases in which simple mastectomy had been done for a benign lesion, a radical mastectomy having been done previously on the opposite side for a malignant lesion. During 1942, question-



naires were sent to patients who had not been seen at the clinic within the past six months. Since all the patients had been operated on in 1935 and 1936, the follow-up period was five to six years. Three hundred eighty-two patients (86.4 per cent) were traced and it is from this group that the final results were derived (Table I).

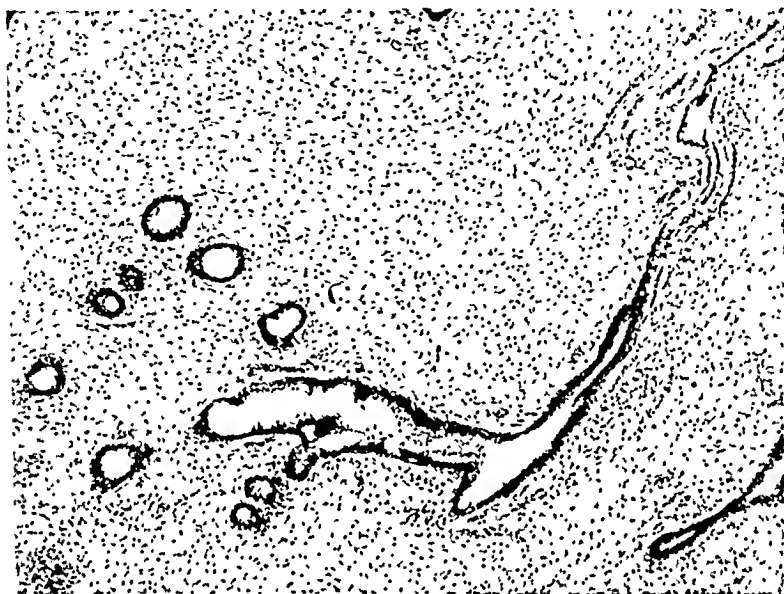


Fig. 3.—Fibroadenoma; an area showing both intracanalicular and pericanalicular types.



Fig. 4.—Comedomastitis; the thick walled ducts are filled with a noncellular homogeneous material.

TABLE I

FOLLOW-UP DATA IN 382 CASES OF BENIGN LESIONS OF THE BREAST

PATHOLOGIC TYPES	NUMBER OF PATHOLOGIC TYPES FOUND	CASES	CARCINOMA DEVELOPED	
			CASES	PER CENT
Chronic cystic mastitis	213	183	6	3.3
Fibroadenoma	124	109	0	0
Chronic mastitis	70	64	1	1.6
Comedomastitis	19	18	0	0
Miscellaneous conditions	8	8	0	0
Total	434	382	7	1.8

In seven (1.8 per cent) of the entire number of cases traced, carcinoma of the breast developed subsequently. None of these malignant lesions developed in a breast which had previously given rise to more than one type of benign lesion. Carcinoma was not found to occur in any of the cases of fibroadenoma or comedomastitis. However, carcinoma did develop among patients who previously had had chronic cystic mastitis (3.3 per cent) or chronic mastitis (1.6 per cent).

Two (28.6 per cent) of the seven patients who subsequently had carcinoma of the breast were past the menopause when they were first seen at the clinic. However, about 25 per cent of the entire group of patients had passed the menopause when they were originally seen, so that no definite conclusions may be drawn from this series of cases in regard to the effect of endocrine imbalance on the development of carcinoma of the breast.

## COMMENT

We are well aware of the fact that such a study as this will not result in a final answer. We would like to be able to read the future and state exactly how many more patients will have carcinoma as they become older and reach the ages at which carcinoma of the breast is more likely to occur. However, the one finding that results from this five- to six-year follow-up study, which we may state as factual, is that 7 (1.8 per cent) out of 382 patients who previously had had a proved benign lesion of the breast, subsequently had carcinoma. This results in a yearly attack rate of about 0.30 per cent for this group.

The death rate for carcinoma of the breast in the state of Minnesota in 1940 was twenty-nine per 100,000 for women of all ages or thirty-one per 100,000 for women in the ages from 25 to 65 years.<sup>14</sup> It is the latter figure with which we are concerned in this study for it more closely resembles the ages of the patients in this series, and the mortality rate of this group from cancer of the breast was 0.031 per cent in Minnesota in 1940. Warren<sup>20</sup> stated, and we believe rightly so, that multiplying the mortality rate by two gives a fairly accurate figure for the morbidity or attack rate of carcinoma of the breast. This results in a yearly attack rate in the general population of 0.062 per cent and an attack rate in our series of patients with previously proved benign

disease of the breast, of 0.30 per cent. In other words, the incidence of cancer of the breast in this series was five times as great as was the incidence of cancer of the breast in the general population of women from 25 to 65 years of age in 1940 in Minnesota.

#### SUMMARY AND CONCLUSIONS

An attempt was made to trace 442 patients five to six years after surgical treatment at the clinic for benign lesions of the breast; 86.4 per cent of these patients were traced.

Carcinoma of the breast subsequently developed in seven cases, a crude attack rate of 1.8 per cent in the five- to six-year period.

Carcinoma was not reported in any case of fibroadenoma or comedo-mastitis, but it did develop in the groups of patients who had had chronic cystic mastitis (3.3 per cent) and chronic mastitis (1.6 per cent).

The incidence of carcinoma of the breast in the entire series was five times as great as was the incidence of carcinoma of the breast in the population of women from 25 to 65 years of age in Minnesota for the year 1940. Such findings emphasize the importance of following closely patients with cystic disease of the breast in order to observe any recurrence of a benign condition or a possible development of a malignant process.

#### REFERENCES

1. Billroth, T.: Quoted by Campbell, O. J.<sup>5</sup>
2. Bloodgood, J. C.: Quoted by Patey, D. H.<sup>15</sup>
3. Brissaud, M.: Quoted by Campbell, O. J.<sup>5</sup>
4. Brodie, B. C.: Quoted by Lewis, D., and Geschickter, C. F.<sup>13</sup>
5. Campbell, O. J.: Relationship Between Cystic Disease of the Breast and Carcinoma, *Arch. Surg.* 28: 1001-1056, 1934.
6. Charteris, A. A.: Quoted by Patey, D. H.<sup>15</sup>
7. Cheatle, G. L., and Cutler, M.: Tumors of the Breasts; Their Pathology, Symptoms, Diagnosis and Treatment, Philadelphia, 1930, J. B. Lippincott Company, 596 pp.
8. Cooper, A. P.: Quoted by Lewis, D., and Geschickter, C. F.<sup>13</sup>
9. Davis, H. H.: Cystic Disease of the Breast, *SURGERY* 10: 663-674, 1941.
10. Fraser, J.: Quoted by Patey, D. H.<sup>15</sup>
11. Handley, W. S.: Quoted by Patey, D. H.<sup>15</sup>
12. König, F.: Quoted by Davis, H. H.<sup>9</sup>
13. Lewis, D., and Geschickter, C. F.: Relation of Chronic Cystic Mastitis to Carcinoma of the Breast, *Surg., Gynec. & Obst.* 66: 300-307, 1938.
14. Minnesota Department of Health: Cancer Deaths in Minnesota, March 31, 1942.
15. Patey, D. H.: Chronic Cystic Mastitis and Carcinoma; Collective Review, *Surg., Gynec. & Obst.* 68: 575-579, 1939.
16. Reclus, P.: Quoted by Campbell, O. J.<sup>5</sup>
17. Schimmelbusch, C.: Quoted by Campbell, O. J.<sup>5</sup>
18. Semb, C.: Quoted by Patey, D. H.<sup>15</sup>
19. Virchow: Quoted by Davis, H. H.<sup>9</sup>
20. Warren, Shields: The Relation of "Chronic Mastitis" to Carcinoma of the Breast, *Surg., Gynec. & Obst.* 71: 257-273, 1940.

## STUDIES ON TRAUMATIC SHOCK

### II. THE RESTORATION OF BLOOD VOLUME IN TRAUMATIC SHOCK\*

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**S**TUDIES on the restoration of blood volume after traumatic shock are of practical importance because many patients in shock as a result of trauma usually need fairly active treatment for some hours or days after the initial shock has been successfully treated. This treatment may require a surgical operation, considerable change of position due to the need for further x-ray studies, subsequent blood transfusions because of redevelopment of shock, and means for combating a serious infection; the problems mentioned are only a few that might possibly arise.

There is at present a paucity of reliable observations on the rapidity with which blood volume is restored after a patient has recovered from the initial symptoms of traumatic shock. Unfortunately for the shock patient, too many persons place false reliance on the fact that in hemorrhage resulting in a small external loss of blood there is an almost immediate readjustment of blood volume by the drawing in from the extravascular spaces of protein-poor fluid, and consider that the same protective mechanisms operate readily and efficiently in traumatic shock.

We can discover only a few reliable observations that bear on this discussion as far as the human shock subject is concerned. Keith,<sup>1</sup> as pointed out in the earlier report,<sup>2</sup> determined for the first time the circulating blood volume in wounded soldiers in shock from serious wounds. At regular intervals after recovery from shock the blood volume was redetermined on several of these wounded individuals. Keith's observations and conclusions have been criticized strongly (and we believe probably unwisely) on technical grounds because he employed the vital red method for the estimation of plasma volume; it is now well known that with repeated determinations of blood volume by the vital red method, serious errors may be involved in the calculation of blood volume. However, Keith observed that although recovery from wound shock was associated with an increase in blood volume, this increase might in certain individuals be very slow, the normal blood volume level being attained only after three to five days.

Ebert, Stead, and Gibson<sup>3</sup> studied the rate of blood volume restoration in normal subjects from whom moderate amounts of blood had been

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rapidly withdrawn. Circulatory collapse of short duration was produced but not of a degree severe enough to be termed hemorrhagic shock. In these individuals no attempt was made to restore blood volume by blood or plasma infusions. An analysis of their protocols shows that in four of the six subjects studied, the plasma volume had approached normal levels in eight hours (all in twenty-four hours); there was, however, some delay in the restoration of total circulating protein. Later studies by Ebert and associates<sup>4</sup> indicated that when this same procedure was carried out on dogs, but the animals kept in a state of hemorrhagic shock for twelve hours by the steady withdrawal of sufficient blood (after the initial bleeding) to maintain the blood pressure at shock levels, plasma volume restoration and protein replacement were decidedly slow.

We became interested in this matter of blood volume restoration in traumatic shock patients after observing in several cases the death of such patients on the second or third day (after trauma had been received), when the only thing done to the patient was to change radically his position in bed. One patient, for example, after having recovered from the initial severe shock after treatment with one blood transfusion, on the third day had a normal blood pressure, slightly elevated pulse rate, and no typical signs of shock. He was raised in bed to a better position for chest examination, when he suddenly expired. Another shock patient, similarly treated for severe traumatic shock, expired shortly after he had been moved on his side for a spinal tap on the third day after admission.

We were under the impression that the cause of death in these patients was probably a poor adjustment in the circulatory flow to the vital centers with a sudden change in body position, and being unaware of Keith's observations on the restoration of blood volume in shock with recovery, we carried out the present study.

#### METHOD

In the preceding article,<sup>2</sup> we outlined the plan of study for the estimation of blood volume of patients in shock as a result of severe trauma. From this larger group of patients in severe shock, there were selected eighteen patients (mostly with compound fractures of femur, or tibia and fibula). To each of these patients was given initially, after a plasma volume estimation was completed, enough blood or plasma to bring them out of shock, and restore blood pressure readings to normal levels. From that time on, no more blood or plasma was given for five to six days. They were placed on a liquid diet the day after admission, a soft diet on the third and fourth day, and if possible on a general diet on the fifth day after admission. No intravenous therapy was given; water by mouth was not withheld. A blood volume estimation was carried out at twenty-four-hour intervals, under basal conditions, until the plasma volume had returned to normal levels.

Any plasma protein accompanying the observed increase in plasma volume taking place after the initial shock had been treated must be considered, therefore, to have come from the protein storage depots or regenerated from ingested protein. The former is almost surely the case, because the protein intake on the diets used in the study period is admittedly quite low.

Plasma volume estimations were made by the Gregeisen-Gibson dye method<sup>5</sup> as adapted to the Klett photocolormeter. The hematocrit was determined by centrifuging blood specimens at 2,500 revolutions per minute in the Sanford-Magath 6 c.c. tube. The total cell volume was calculated from the plasma volume and the hematocrit reading; the plasma protein was determined by the falling drop method of Kagan.<sup>6</sup> The total circulating protein, in grams, was obtained by multiplying the plasma protein concentration in grams per 100 c.c., by the plasma volume, in hundreds of cubic centimeters. All samples of blood were taken without stasis.

Of the eighteen shock patients studied in this manner, six patients were selected for this report. The results obtained are representative of the group as a whole.

#### CASE REPORTS

**CASE 1 (M. H.).—***Diagnosis:* Avulsion of scalp; blood loss, abrasion of abdomen, arms, and legs.

The patient was a 28 year old woman who had been thrown down a hillside when a car overturned. On entry to the hospital she was screaming with pain and was irrational. Blood pressure was 90/50; pulse, 100 (poor quality); plasma volume, 25 c.c. per kilogram. She was brought out of shock with only 1,000 c.c. saline and thereafter was given only intravenous glucose. She recovered full consciousness slowly. Recovery was complete with no infection of scalp or abrasions. Abrasions were treated by sulfanilamide gauze pressure dressings.

**CASE 2 (H. L.).—***Diagnosis:* Traumatic amputation of left leg; severe secondary shock.

The patient was a 27 year old man whose left leg had been run over by a train shortly before admission. He had been treated at the scene of accident by a physician who placed a tourniquet above the traumatized area of the leg. Examination showed profuse sweating of forehead and extremities. Pulse was 100, with fair volume and good venous filling. Extremities were cold; blood pressure, 130/50, falling soon after admission to 70/50, when pulse became rapid and thready. Plasma volume was 28.9 c.c. per kilogram. The injured leg was amputated above the knee under pentothal anesthesia, following which the patient was given 500 c.c. whole blood, his blood pressure rising to 100/60. Thereafter no more blood or plasma was given for four days; full recovery.

**CASE 3 (J. W.).—***Diagnosis:* Compound fracture of right tibia, fibula; fracture of pelvis; fracture of neck of right femur.

The patient was a 68 year old man who had been struck by a car fifteen miles from Richmond. The leg was splinted properly, the patient given morphine and

brought to the hospital by private car. On entry, the pulse was 110, fair volume; no sweating, but venous filling only fair. Blood pressure was 125/60 on entry, but fell in thirty minutes to 70/50. Given 250 c.c. of 5 per cent glucose, pressure rose to 128/70. Plasma volume on admission was 25 c.c. per kilogram. Given 500 c.c. of whole blood, the patient's blood pressure rose to 140/90. Under ether anesthesia, the compound fracture was reduced and a cast applied. Blood pressure fell to 100/60, so 250 c.c. of plasma were given, with a rise of blood pressure, thereafter maintained, to 120/70. After operation 500 c.c. of whole blood were given; thereafter no blood or plasma. Recovery was complete.

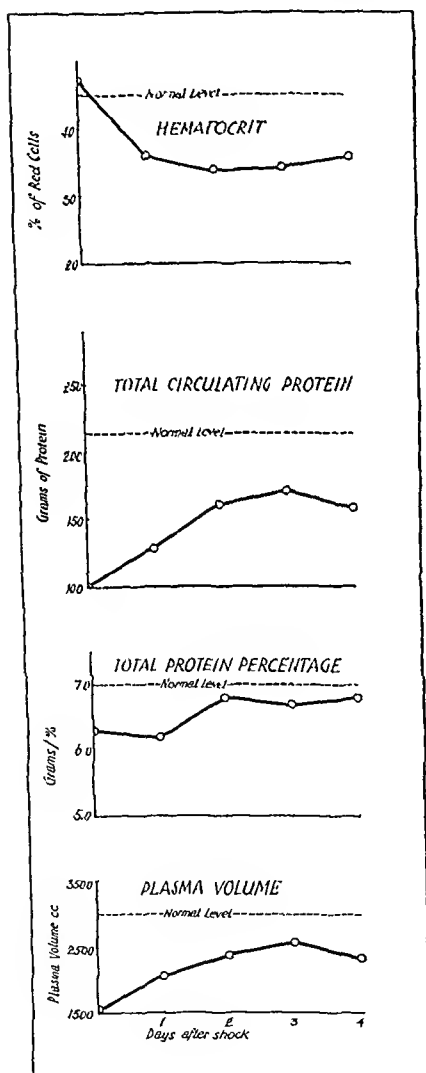


Fig. 1.

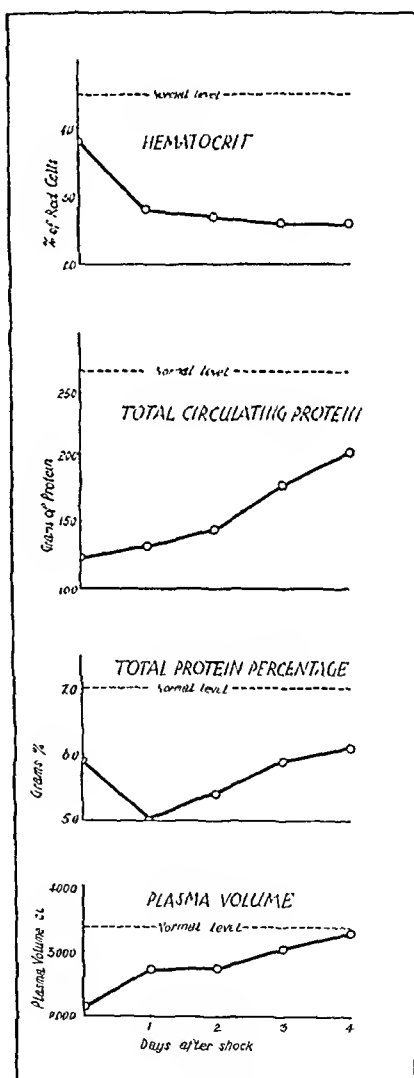


Fig. 2.

Fig. 1.—Case M. H. Restoration of blood volume in patient who had suffered severe body trauma. Plasma volume and total circulating protein showed marked deficit on the fourth day.

Fig. 2.—Case H. L. Restoration of blood volume in patient who had received severe trauma to lower limb, requiring amputation. Plasma volume and total circulating protein assumed practically normal levels by the fourth day, but hematocrit remained low.

CASE 4 (R. H. M.).—*Diagnosis:* Comminuted fracture of right femur.

The patient was a 20-year-old man who suffered fracture of the right femur in an automobile accident fifty miles from Richmond. He was brought by private car to the hospital without any attempt at splinting of the leg. At the time of entry he showed marked pallor, mucous membranes, and slight cyanosis. Venous filling was only fair and extremities were cool with no sweating. Pulse rate was 106; blood pressure, 90/60; plasma volume, 25.2 c.c. per kilogram. The leg was placed in a Thomas splint; 1000 c.c. of 5 per cent glucose brought the pressure to 126/80; thereafter, given 500 c.c. of whole blood, his pressure rose to, and stayed there-

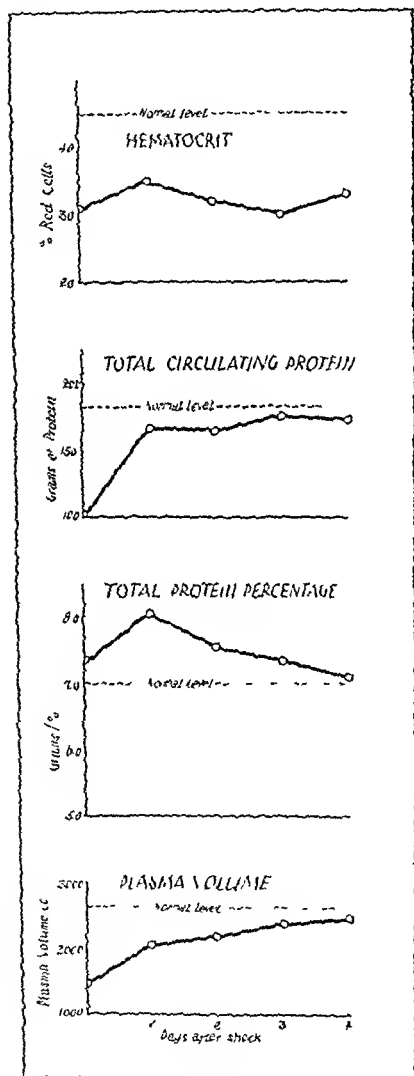


Fig. 3.

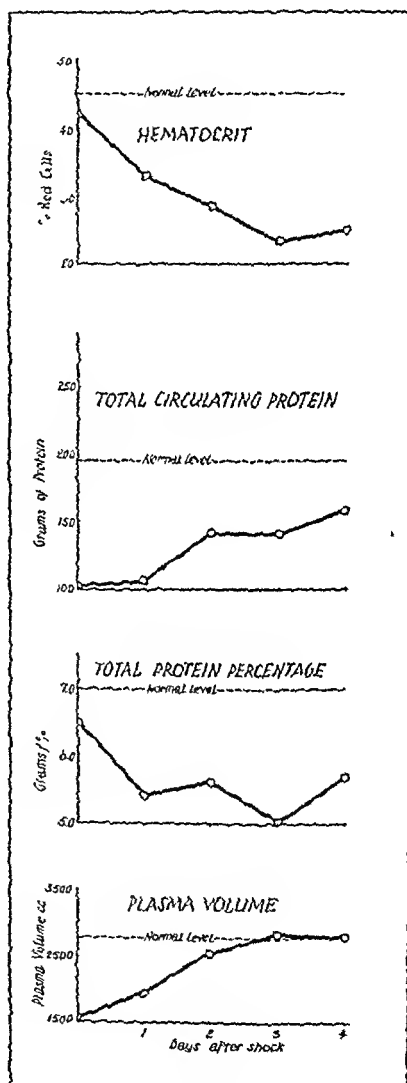


Fig. 4.

Fig. 3.—Case J. W. Restoration of blood volume in patient who suffered severe fractures of lower limbs and pelvis; slow restoration of plasma volume and total circulating protein. Hematocrit remained low despite 1,000 c.c. of whole blood in treatment of shock.

Fig. 4.—Case R. H. M. Comminuted fracture of femur. Total circulating protein not restored to normal level by fourth day and severe anemia persisted.



after at, 130/80. Plaster cast was put on and reduction done the next day. There was full recovery.

CASE 5 (T. W.).—*Diagnosis*: Fracture of pelvis; secondary shock.

The patient, a 23-year-old woman, was injured in an auto collision with a truck. She was brought to the hospital in a private car. On arrival she presented a picture of severe shock; pulse, 136, weak and of poor volume; upper extremities cold and clammy, lower extremities cold. Blood pressure was 70/50; plasma volume 33 c.c. per kilogram; 750 c.c. of saline were given with no response. When 25 Gm. of human albumen were given, pulse volume was greatly improved, rate dropped

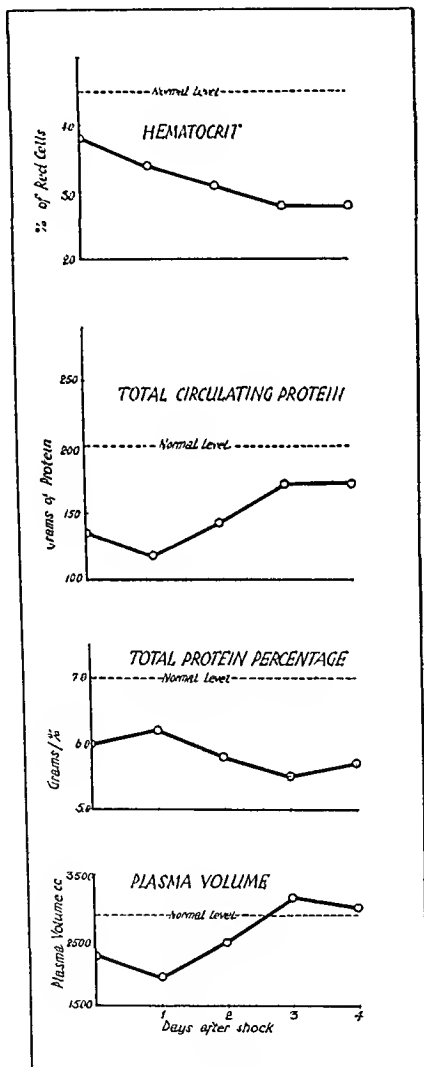


Fig. 5.

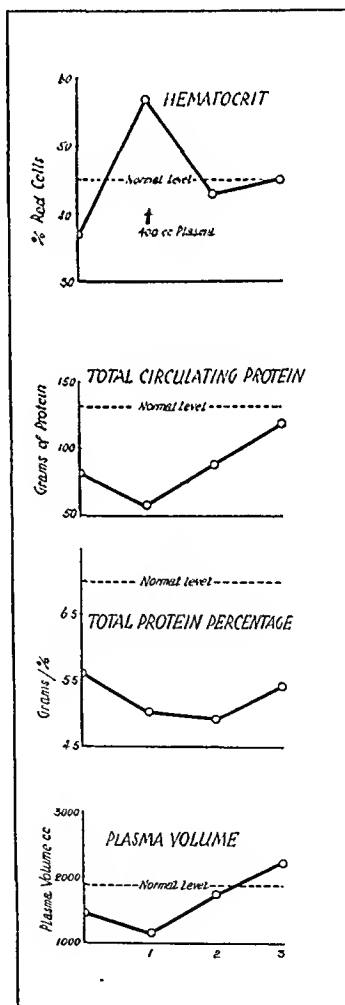


Fig. 6.

Fig. 5.—Case T. W. Fracture of pelvis. Total circulating protein was not restored by the fourth day and hematocrit remained very low.

Fig. 6.—Case M. J. Stab wound of abdomen. Patient received large amounts of whole blood. Hematocrit and plasma volume returned to normal levels on the second day, indicating the benefits of whole blood transfusions.

to 104, blood pressure rose to 88/50, and later to 100/70. Thereafter there was no further blood or plasma therapy. Full recovery took place.

CASE 6 (M. J.).—*Diagnosis*: Stab wound of abdomen; perforation of stomach; severed mesenteric artery.

The patient was an 18-year-old girl who was brought to hospital soon after receiving a stab wound of the abdomen. On examination, there were signs of severe shock. Blood pressure was unobtainable, limbs were cold and wet, and there was marked restlessness. Pulse rate was 140 (precordial); plasma volume, 30 c.c. per kilogram. Glucose, 100 c.c. of 5 per cent, and 500 c.c. of whole blood brought the blood pressure to 50/0, the pulse down to 124. Whole blood, 500 c.c., was started and the patient was taken to the operating room where celiotomy was carried out under intercostal block-pentothal anesthesia. When the abdomen was opened, considerable blood was encountered. The patient continued in severe shock until a severed mesenteric artery, freely bleeding, was ligated. During operation and in the ensuing nine hours the patient was given a total of approximately 2,500 c.c. of whole blood, with blood pressure finally rising to 120/80. Thereafter, because of high hematocrit (57 per cent) the following day, 400 c.c. of plasma were given. Recovery was complete.

## RESULTS

*A. Quantitative Aspects of Blood or Plasma Replacement in Relief of Traumatic Shock.*—It is currently rather widely held that the amount of blood or plasma required to bring a patient out of shock indicates accurately the extent of blood or plasma loss in the patient. This impression has led some to discredit the "blood loss" theory of shock. They hold that if traumatic shock is due to blood or plasma loss, then there should be a good correlation between severity of shock and the amount of blood or plasma necessary to restore the blood pressure to normal levels. Although within certain well-defined limits this may be true, analysis by us of an abundant mass of blood volume data on shock patients shows without any doubt that a patient may be in severe shock from trauma (compound or simple fractures of femur, tibia, or pelvis), have a greatly reduced circulating blood volume, yet show a return of blood pressure to normal levels (and disappearance of other shock signs) with only enough blood or plasma to raise the plasma volume 2 to 3 c.c. per kilogram. A study of the case reports illustrates this fact. Although some of these shock patients had lost so much blood that the plasma volume was in the neighborhood of 25 c.c. per kilogram (normal being 45 c.c. per kilogram), only 250 c.c. of plasma or 500 c.c. of whole blood brought about a significant rise in blood pressure and recovery from shock.

Our experience in treating many shock patients supports these contentions: first, the severity of shock correlates well with the extent of blood loss as determined by blood volume estimation (dye technique); although this is true, the amount of blood or plasma necessary for full immediate recovery from shock may be no indicator of the severity of blood loss in a given instance.

Hence, we view with suspicion any claims that in a given case of severe shock the cause of shock must be other than a seriously reduced circulating blood volume because the patient's blood pressure was restored immediately and promptly by only a small transfusion of one pint of blood or plasma. Such claims become valid only when supported by blood volume data.

*B. Changes in Plasma Volume Following Traumatic Shock.*—It is becoming clearly apparent that reduction in circulating blood volume is a significant factor in the causation of traumatic shock (Keith; Blacklock; Phemister; Gregersen; Evans), so we can expect to find a lowered plasma volume if the estimation is made soon after the trauma has been received. Examination of the plasma volume data of the six patients reported here (Table I, and Figs. 1 to 6) indicates that following the initial treatment for shock, the plasma volume increases only gradually for three to four days; usually a level approximating normal is reached only after seventy-two hours or more. In no patient was there a sudden large increase in plasma volume following shock.

*C. Relation of Plasma Volume Changes to Plasma Protein Concentration.*—Reference to Table I, Figs. 1 to 6, shows that there is no true relation of plasma volume changes to changes in plasma protein concentration, although in some patients not mentioned in detail in this report there seemed to be a tendency toward slight increase in plasma volume by the drawing into the blood stream of fluid poor in protein, especially in the first twenty-four hours after shock. It is clear, however, that there seems to be a definite relation between total circulating protein available and a change in plasma volume. It appears that there is a definite tendency to maintain normal osmotic pressure relationships in the restoration of plasma volume, plasma volume not increasing unless there is an increase in total circulating protein.

*D. Changes in Hematocrit Reading and Red Cell Volume.*—Each time a plasma volume determination was made it was possible to get accurate information on the hematocrit levels in at least five hematocrit tubes. Although the calculation of total red cell volume from hematocrit and plasma volume data may be open to some error, for clinical purposes the information gained may be valuable. From Table I, Figs. 1 to 6 it can be seen that in every shock patient (except M. J., who received massive whole blood transfusions) there was a serious fall in the hematocrit level, with no tendency toward return to normal values by the fourth day. Also, calculations of total red cell volume (Table I) indicate that on the fourth day the red cell mass is about the same as existed when the first blood volume determination was made, unless large amounts of whole blood were employed in the initial treatment of shock (see Table I, patients J. W. and M. J.).

Although the decrease in hematocrit readings at twenty-four hours after shock usually paralleled the increase in plasma volume, after that

TABLE I

DATE	HEMA- TOCRIT READ- ING	TOTAL PRO- TEIN (GM. %)	PLASMA VOLUME (C.C.)	RED CELL VOLUME (C.C.)	TOTAL CIRCULATING PRO- TEIN (GM.)	COMMENTS
M. H. (Case 1)						
6/20/43	47	6.3	1564	1378	98.7	Given only 1,000 c.c. saline
6/21/43	36	6.2	2062	1162	128.0	
6/22/43	34	6.8	2378	1250	161.8	
6/23/43	34.5	6.7	2565	1351	172.0	
6/25/43	36	6.8	2340	1318	159.0	
H. L. (Case 2)						
5/20/42	38	5.9	2169	1330	127.9	Given 500 c.c. whole blood
5/21/42	28	5.0	2721	1060	136.1	
5/22/42	27	5.4	2751	1017	148.5	
5/23/42	26	5.9	3080	1082	181.7	
J. W. (Case 3)						
9/20/43	31	7.3	1490	670	104.2	Given 1,000 c.c. blood, 250 c.c. plasma
9/21/43	35	8.0	2033	1092	166.0	
9/22/43	32	7.5	2192	1030	165.0	
9/23/43	30	7.3	2389	1024	175.5	
9/24/43	33	7.1	2450	1208	174.0	
R. H. M. (Case 4)						
9/ 4/42	42	6.1	1565	1132	95.0	Given 500 c.c. whole blood
9/ 5/42	33	5.4	1954	965	106.0	
9/ 6/42	28.5	5.6	2530	1008	142.5	
9/ 7/42	23.5	5.0	2831	869	142.0	
9/ 8/42	25	5.7	2800	934	159.0	
T. W. (Case 5)						
7/20/43	38	6.0	2250	1380	135.0	Given 25 Gm. human albumen
7/21/43	34	6.2	1911	985	118.5	
7/22/43	31	5.8	2476	1112	143.5	
7/23/43	28	5.5	3149	1225	173.5	
7/24/43	28	5.8	3000	1169	174.0	
M. J. (Case 6)						
9/30/42	37	5.6	1446	734	81.0	Given 2,500 c.c. whole blood
10/ 1/42	57	5.0	1157	875	58.3	Given 400 c.c. plasma
10/ 2/42	43	4.9	1764	1330	87.0	
10/ 3/42	45	5.4	2207	1810	119.5	

time these readings appear not to be a useful guide in estimating the rate at which plasma volume may be increasing. (This lack of correlation between hematocrit readings and plasma volume estimation we have found also in unpublished studies on severely burned patients.)

## COMMENT

These experiments show that after a patient has suffered trauma accompanied by blood or plasma loss severe enough to reduce the blood volume from 25 to 40 per cent, there is only a gradual, slow restoration of plasma volume. Even after three or four days, the plasma volume

may not have returned to a normal level. Although plasma volume estimation is undoubtedly more exact with the T-1824 dye technique, there seems now no doubt that Keith's studies gave fairly accurate information on this point in 1918.

A comparison between the rate of plasma volume restoration in these studies and those reported by Ebert, Stead, and Gibson<sup>3</sup> indicate that in the human subject plasma volume restoration is much slower after traumatic shock than after simple hemorrhage without shock. This was to be expected from the experiments on the dog in shock by Ebert and co-workers,<sup>4</sup> which indicated that mechanisms responsible for the elaboration or liberation of protein are probably impaired if the shock state exists for a moderately long period of time.

From a practical point of view, regarding the subsequent treatment of a person who has recovered from the immediate effects of severe traumatic shock, certain deductions are pertinent. It is obvious that the determining factor in the restoration of plasma volume in the shock patient is early and adequate quantitative replacement of circulating plasma protein. From the studies herein reported (and those of Ebert, Stead, Warren and Watts<sup>4</sup>), it is likely that large amounts of protein are not added to the blood stream early after hemorrhage or shock simply because protein depots with *readily available plasma protein* do not exist. Protein for the circulation must first be elaborated from protein stores or from protein that has been made available for this use by oral or intravenous administration of the building materials. For these reasons it is imperative that the treatment of the shock patient (regarding protein therapy) not end with bringing the patient out of shock, but be continued in the form of (1) enough plasma to restore plasma volume to normal levels (in the ordinary shock patient this would require from 1,000 to 1,500 c.c. of plasma) or (2) enough amino acids so that from 100 to 200 Gm. of protein can be elaborated (see Elman and associates<sup>7</sup>), or (3) a diet high in protein. In these first few days after shock has been sustained, the caloric intake of the patient must be kept high by carbohydrate therapy, so the plasma, amino acid, or protein (diet) given is available for protein replacement and not used for energy requirement.

The subjects used in these experiments had been, as a general rule, on fairly adequate diets before shock was sustained; it is likely, therefore, that their protein stores were at fairly normal levels. In them, as we have seen, plasma volume and total circulating protein restoration was slow (three to four days). The problem of protein replacement with this group is real, but would have been quite serious if their daily protein intake had been, say, from 30 to 40 Gm. per day, for months prior to injury. Such persons, as now must exist by the thousands in occupied Europe at this time, barely maintain a level of plasma volume to ensure only fair circulation. In such persons injuries accompanied

by blood loss (shock) will present almost insurmountable problems in restoration of blood volume after injury.

In addition, restoration of plasma volume and total circulating protein from adequate stores in our subjects was not complicated by the problem of infection. In protein-depleted persons, such as those in occupied Europe, or our own troops in the forward areas for great lengths of time, on insufficient protein rations, protein must be made available in the early days after injury not only to restore plasma volume but also to replace the protein matrix of the cell so that there exists in the injured person adequate capacity to produce antibodies (globulins) to combat infection (see Cannon<sup>5</sup>). Perhaps one of the main beneficial effects of blood transfusions after injury or a surgical operation is the restoration of this cellular capacity to produce antibodies.

In certain forward areas of combat where there are many traumatic shock patients, the supplies of plasma will be sorely taxed for the early and immediate treatment of shock. Not enough plasma will remain to restore fully the plasma volume to normal levels. When adequate plasma volume replacement cannot be accomplished because of inadequacy of supply, medical officers caring for individuals after immediate recovery from shock should take every precaution to change the patient's position with great care. If possible, transport should be carried out with the patient in the head-down position (except possibly head and chest wounds). If a surgical operation must be done, careful judgment should be exercised in the choice and administration of the anesthetic.

In our more recent enthusiastic acceptance of plasma infusions in the therapy of traumatic shock, surgeons have tended to forget that red blood cells, as well as plasma, are lost from the blood stream in traumatic injuries. Reference to Figs. 1 to 6 shows that there are apparently no reserves of red cells available for replenishment, either in the case of emergency or for three to four days following trauma. Therefore, proper replacement therapy for shock caused by trauma or acute hemorrhage calls for whole blood, not plasma alone. Plasma should be given as an emergency measure, to be followed soon after by whole blood in amounts quantitatively to replace the red blood cells lost; otherwise, secondary anemia will be present invariably in all traumatic shock patients for days after the injury. Plasma protein is replaced in the immediate period only slowly after shock, red blood cells hardly at all. This may indicate a selective priority of protein stores for the production of plasma protein, rather than for the elaboration of hemoglobin.

#### SUMMARY AND CONCLUSIONS

1. Loss of blood or plasma in traumatic shock is associated with only a slow restoration of plasma volume. Three to four days may be required for the attainment of normal plasma volume levels.

2. After shock, the plasma volume is not restored to normal until new plasma protein is drawn into the circulation. Plasma volume is not restored after shock by replacement with protein-poor fluids withdrawn from the extravascular system.

3. There are apparently no red cell reserves available for replenishment of red blood cells lost in traumatic shock, either immediately or for three to four days after the injury.

4. The proper therapy for traumatic shock after the emergency treatment with plasma requires the administration of adequate amounts of whole blood to replace red blood cells lost.

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#### REFERENCES

1. Keith, N. M.: Blood Volume Changes in Wound Shock and Primary Hemorrhage, IX, Medical Research Committee Reports, London, 1919.
2. Evans, E. I., Hoover, M. J., James, G. Watson, III, and Alm, T.: Studies on Traumatic Shock: I. The Relation of Blood Volume to Shock, *Ann. Surg.* 119: 64, 1944.
3. Ebert, R. V., Stead, E. A., and Gibson, J. G., Jr.: Response of Normal Subjects to Acute Blood Loss, *Ann. Int. Med.* 68: 578, 1941.
4. Ebert, R. W., Stead, E. A., Jr., Warren, J. V., and Watts, W. E.: Plasma Protein Replacement After Hemorrhage in Dogs With and Without Shock, *Am. J. Physiol.* 136: 299, 1942.
5. Gibson, J. G., II, and Evelyn, K.: Clinical Studies of Blood Volume, *J. Clin. Investigation* 17: 153, 1938.
6. Kagan, B. M.: A Simple Method for the Estimation of the Total Protein Content of Plasma and Serum, *J. Clin. Investigation* 17: 373, 1938.
7. Elman, R., Weiner, D. O., and Bradley, E.: Intravenous Injections of Amino-Acids in Postoperative Patients, *Ann. Surg.* 115: 1160, 1942.
8. Cannon, P. R.: Antibodies and Protein Reserves, *J. Immunol.* 44: 107, 1942.

# CARDIOPULMONARY DISTURBANCES ASSOCIATED WITH MEDIASTINAL DISPLACEMENT AFTER PNEUMONECTOMY

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**M**EDIASTINAL displacement in the early postoperative period after total pneumonectomy may cause clinically significant alterations in the cardiocirculatory and respiratory function. Repeated adjustments of the intrapleural pressure on the side operated upon may be necessary in some cases in order to maintain a relatively median position of the mediastinum during the first few weeks after pneumonectomy. The present report is concerned with the causes, the effects, and the control of significant mediastinal deviation shortly after the operative procedure. The later effects of pneumonectomy on cardiopulmonary function have been previously reported by Cournaud and Berry,<sup>1</sup> and by Lester, Cournaud, and Riley.<sup>2</sup>

The mediastinum may be shifted to the side operated upon because of a highly negative pressure in the pleural space from which the lung was removed, or the mediastinal partition may be displaced toward the contralateral side by a large amount of air or fluid on the side of the operation. The time factor is very important in evaluating the effect of mediastinal displacement. Whereas a shift of the mediastinal partition which occurs gradually may cause few or no symptoms, and result in only slight cardiopulmonary maladjustment, a similar degree of displacement occurring rather suddenly may cause serious alteration in the respiratory and cardiocirculatory function. It is of the utmost importance that the degree of mediastinal displacement be minimized in the early postoperative period after total pneumonectomy, especially in the elderly and poor-risk group of patients. Intrapleural pressure readings must be taken at the conclusion of the operative procedure and at intervals in the postoperative period. In addition, roentgenograms should be taken on the first or second postoperative day, and then at intervals of a few days. Roentgen examination is the only certain way of determining the degree of mediastinal displacement due to fluid accumulation on the side from which the lung was removed.

Several factors will determine the amount of air which is trapped in the pleural space at the time the thorax is closed without drainage after pneumonectomy. The position of the mediastinum may be influenced by (1) the position of the patient on the operating table, (2) the degree of

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inflation of the remaining lung, (3) the amplitude of the respiratory and mediastinal excursion at the time the thorax is closed, and the phase of respiration in which the sutures are tied which render the closure of the chest wall airtight, and (4) whether the thoracic incision acts like a sucking wound when it is almost closed. If closed drainage is employed the problem is altered, but other additional factors must be considered.

If the pneumonectomy has been performed through an anterior approach with the patient lying in the supine position, there tends to be little deviation of the mediastinum to the contralateral side during quiet breathing while the pleural cavity is open. This factor tends to favor a median position of the mediastinum at the time that the chest wall is closed after a pneumonectomy performed through an anterior approach, and the intrapleural pressure on the side operated upon is, therefore, usually nearly atmospheric or slightly subatmospheric. In contrast to this is the situation encountered when the patient is operated upon in the lateral recumbent position where there is a greater tendency for the mediastinum to be displaced to the opposite side and to limit the expansion of the dependent lung, and there is a tendency to trap more air in the pleural space when the chest wall is closed.

The anesthetist controls the degree of inflation of the remaining lung, which in turn affects the position of the mediastinum. The amount of air left in the pleural space on the side operated upon, as the thoracic wall is closed, will be influenced by this factor.

If the patient is breathing quietly at the time the thoracic wound is rendered airtight, the chance of trapping much excess air within the thorax is minimized. If a large respiratory excursion is present and the final sutures which make the wound airtight are tied during or at the end of inspiration, considerable additional air may be trapped within the pleural space.

As the thoracic wall is being closed after an intrapleural procedure it is not uncommon to have the effect of a sucking wound until the closure has been rendered airtight. The opening between the sutures may permit the entrance of air into the pleural space during inspiration but only permit a small portion of this air to be expelled during expiration. The maintenance by the anesthetist of a slightly positive intratracheal pressure during the closure of the thoracic wall does not eliminate the accumulation of air in the pleural space which may result from this sucking mechanism. By this means it is possible for considerable quantities of air to be trapped within the pleural space. If a large piece of well-moistened gauze is placed over the sucking areas of the chest wound, the entrance of air into the pleural space will be considerably diminished.

An intrapleural pressure, which is slightly subatmospheric when the patient is in the lateral recumbent position with the pneumothorax side upward, may be changed into a positive pressure when the patient is

placed with the pneumothorax side dependent. On several occasions a rather sudden drop in blood pressure and alteration in the character of the pulse have been observed when the patient's position was changed at the conclusion of a long intrathoracic procedure. It must be borne in mind that variations in intrapleural pressure which might not significantly affect the circulation of a normal individual, may seriously affect a patient verging on circulatory collapse. The poorer the general condition of the patient, the more important any abnormal alteration in intrapleural pressure may be. If the patient is in shock at the conclusion of an intrathoracic operation, the intrapleural pressure must be adjusted to an optimum level before the patient is even moved from the operating table, and again later if necessary. In recording intrapleural pressure readings the position of the patient must be taken into consideration.

When a pneumonectomy is performed without drainage, the position of the mediastinum is controlled by readings and adjustments of the intrapleural pressure by inserting a needle into the space from which the lung was removed. If drainage is instituted because of gross contamination of the pleural space when a pneumonectomy is performed for suppurative disease, a new problem may arise. It is customary in such cases to connect the drainage tube to a water seal. With this setup the patient tends to expel air from the pleural space, especially during coughing, and since no air can re-enter the pleural space because of the water seal, a markedly negative intrapleural pressure may result. The very negative intrapleural pressure may cause rather marked and rapid displacement of the mediastinum toward the side operated upon within the first few hours or days after pneumonectomy. The marked mediastinal deviation may cause a feeling of respiratory distress, and if uncorrected, may have serious and even fatal consequences. Several years ago we observed a patient who showed evidence of circulatory failure on the day following right total pneumonectomy with closed drainage. A roentgenogram taken shortly before the patient's death showed marked retraction of the mediastinum into the side operated upon. Post-mortem examination revealed marked congestion in the overdilated remaining lung. Sometime later another patient subjected to a left pneumonectomy with closed drainage presented a condition simulating shock a few days after operation. At this time the patient had a markedly negative intrapleural pressure on the side operated upon. The highly negative pressure was changed to a slightly subatmospheric pressure with a resultant dramatic improvement in the patient's condition. The following day a similar state of apparent circulatory failure developed and was again corrected by an adjustment of the intrapleural pressure. In a recent case in which drainage was instituted because of marked suppuration, the patient complained of respiratory distress on several oc-

easions within the first twenty-four hours postoperatively and this distress was relieved by making the intrapleural pressure less negative. It should be borne in mind, therefore, that although drainage following pneumonectomy usually eliminates the danger of a tension pneumothorax, it may lead to circulatory disturbances because of the extreme mediastinal deviation to the side of operation, which may occur as a result of the development of a markedly negative intrapleural pressure. The effects of closed drainage in total pneumonectomy are entirely different than in the case of a lobectomy where there is expansion of pulmonary tissue on the side operated upon, which greatly lessens the likelihood of significant mediastinal shift in the early postoperative period. If closed drainage is instituted following pneumonectomy, which as a matter of fact seems rarely necessary, the closed drainage should be so adjusted that not more than a given degree of negative pressure can develop in the system. In a few instances we have observed a markedly negative pressure develop the first few days after operation in the absence of closed drainage. In such instances, because of a poor closure of the deeper layers of the chest wall, a considerable portion of the air which had been left in the empty pleural space at the conclusion of the operation was forced into the tissue planes of the thoracic wall as a result of coughing. The effect was, therefore, much the same as if closed drainage had been employed. The few instances in which we observed this state of affairs were cases in which an anterior intercostal incision had been employed. With this surgical approach it is not possible to get a good closure of the pleural or intercostal muscles and therefore there may be considerable leakage of air into the chest wall. In two such instances several hundred cubic centimeters of air were introduced into the pleural space several days after operation in order to lessen the deviation of the mediastinum.

The more common situation is to note that the intrapleural pressure becomes less negative or even slightly positive in the first few postoperative days after pneumonectomy without drainage as a result of the transudation of considerable fluid into the space which the lung previously occupied. If the fluid accumulates at approximately the same rate as the air is absorbed or leaks into the chest wall, no significant deviation of the mediastinum occurs. If the transudation of the fluid is more rapid, however, the mediastinum may be displaced toward the contralateral side and the ventilation of the remaining lung may be impaired. Measurements of the pressure in the air pockets overlying the fluid do not give accurate information concerning the effect of the fluid accumulation on the position of the mediastinum. We have also found it rather difficult to judge accurately the position of the mediastinum on the basis of physical examination alone. We feel that it is important to ascertain definitely the position of the mediastinal partition by roentgenograms taken at intervals of several days. In one instance in which

the pleural fluid accumulation displaced the mediastinum to the opposite side there were certain clinical findings which suggested that a pericardial effusion might be the explanation of the patient's signs and symptoms, but removal of the excess pleural fluid resulted in a dramatic correction of the difficulties (Case 3). In another case the displacement of the mediastinum to the contralateral side by a large fluid accumulation was associated with a marked irregularity of the pulse. The cardiac rhythm became normal, however, shortly after the position of the mediastinum was corrected by thoracentesis (Case 4). In these two instances there was such a definite improvement in the cardiocirculatory function after the excess pleural fluid was withdrawn that there was no question of the causal relationship. Although it is obvious that considerable mediastinal displacement by fluid would seriously impair the function of the remaining lung, it should be stressed that the mediastinal deviation does not have to be marked in order to be clinically important. The introduction of sulfonamides into the pleural cavity at the time of operation may cause an increase in the amount of transudated fluid in the postoperative period and thus increase the likelihood of mediastinal displacement.

If the patient had no significant cardiocirculatory abnormality before operation, and if there is no emphysema in the remaining lung, the gradual displacement of the mediastinum to the side operated upon, which occurs postoperatively, usually causes no symptoms. If the remaining lung is emphysematous or cardiocirculatory abnormalities exist, the situation may be altered. In one instance a marked cardiac irregularity which occurred one week after pneumonectomy was dramatically corrected by the introduction of air on the side of the operation to lessen the mediastinal displacement (Case 1). In another case an emphysematous remaining lung became so hyperinflated as a result of displacement of the mediastinum to the side operated upon that the ventilatory function was seriously impaired. The patient showed a progressive fall in the per cent saturation of the arterial blood with oxygen during the first three weeks after operation. Usually the arterial oxygen saturation returns to a normal value within the first postoperative week after pneumonectomy.<sup>3</sup> There were signs of beginning circulatory congestion in the emphysematous lung when the mediastinum was replaced in the median line by the introduction of air into the pleural space from which the lung had been removed. Following this the patient's respiratory and circulatory status improved (Case 2).

#### ILLUSTRATIVE CASE REPORTS

CASE 1.—S. T. A right total pneumonectomy was performed on Sept. 16, 1942. The left lung had a moderate degree of pulmonary fibrosis and emphysema. The patient's condition during and at the conclusion of the operation was good. On the day following operation the arterial blood showed a normal oxygen saturation

of 95.6 per cent. On the second postoperative day the trachea and mediastinum were in the midline as determined by roentgen and physical examination. On the third postoperative day the trachea and mediastinum were slightly displaced toward the side operated upon due to the considerable amount of air which had escaped from the right pleural space into the chest wall. There was no respiratory distress and the arterial oxygen saturation was 98.6 per cent. On the sixth postoperative day the patient's general condition appeared good and there was no dyspnea or cyanosis, but the pulse was irregular although not rapid. An electrocardiogram was taken at this time and revealed marked irritability of the heart with a wandering pacemaker. On the following day, the cardiac irregularity had become even more pronounced. The mediastinum was only slightly displaced toward the side of the operation, but, nevertheless, a needle was inserted into the right pleural space, and 300 c.c. of air were introduced. An intrapleural pressure reading was not obtained before the introduction of air because fluid entered the needle, but following the introduction of the air the intrapleural pressure was  $-8$ ,  $+1$ . Within approximately fifteen minutes of this readjustment of the mediastinal position the pulse became regular and remained regular throughout the postoperative period. No digitalis was given.

CASE 2.—D. M. This patient had a carcinoma of the left lung and marked bilateral fibrosis and emphysema. A left total pneumonectomy was performed on Nov. 23, 1940. The immediate postoperative condition was satisfactory. Although the patient's general condition during the first three weeks after operation was quite satisfactory, it was noted that there was a progressive drop in the arterial oxygen saturation from the preoperative level of 91 per cent to a low of 84 per cent in the third week after operation. Associated with this progressive oxygen unsaturation of the arterial blood, there was a gradual deviation of the mediastinum to the side operated upon and marked overexpansion of the remaining emphysematous lung. Râles were then noted in the remaining lung and it was thought by some that a low-grade bronchopneumonia was present. A determination of the residual air at this time yielded the very high value of 71 per cent, indicating the markedly overdistended condition of the remaining lung. It was felt that the mediastinum had to be returned to a more median position in order to permit the emphysematous lung to ventilate more satisfactorily. Therefore, air was introduced into the space from which the lung had been removed. The initial intrapleural pressure was  $-20$ ,  $-8$  and after 240 c.c. of air had been introduced the pressure reading was  $-8$ ,  $0$ . Additional air refills were given on the following days. There was an immediate improvement in the patient's general condition and the râles cleared in the remaining lung. Nine days after the re-establishment of a pneumothorax on the side of the operation, the arterial oxygen saturation had returned to 91 per cent, which was essentially the same as the preoperative level, and there was an associated drop in the residual air and a marked improvement in the patient's respiratory and general condition.

CASE 3.—E. B. This 31-year-old man had a carcinoma of the left lung, and a total left pneumonectomy was performed on Jan. 27, 1940. The patient's condition a few days following operation was quite satisfactory. Two days after operation, the arterial oxygen saturation was 87 per cent. On the fifth postoperative day some irregularity of the pulse was noted. On the ninth postoperative day, the arterial oxygen saturation was 89 per cent, and the general condition fairly satisfactory. On the twelfth postoperative day the patient was quite dyspneic in spite of oxygen inhalations and a definite pulsus paradoxus was present. The venous pressure was 150 cm. of water. The possibility of a pericardial effusion was suspected. After the removal of additional pleural fluid from the side operated upon with correction of the mediastinal displacement to the other side, however, there was an immediate improvement in the patient's condition and the pulse rate again became normal in rate and quality. Actually no pericardial effusion was present.

CASE 4.—C. R. This 53-year-old man had carcinoma of the right lung, and a right total pneumonectomy was performed on Sept. 29, 1942. The postoperative course was satisfactory during the first days, although the temperature was somewhat higher than usual. On the fourth postoperative day an irregularity of the pulse was noted. A roentgenogram at this time showed some displacement of the mediastinum to the side unoperated upon as a result of a large fluid accumulation on the operated side. Removal of the excess fluid with a return of the mediastinum to a more median position resulted in a return of the pulse rhythm to normal within a few hours. No further difficulty was encountered in the postoperative period.

#### DISCUSSION

In an attempt to evaluate the detrimental effects and the clinical significance of any alterations in intrathoracic mechanics, the status of the cardiorespiratory system and the patient's general condition must be taken into consideration. Moderate mediastinal displacement, which might be of no serious importance in an otherwise normal individual, may have marked detrimental effects at the conclusion of a long operative procedure when there is reduction in blood volume and impairment of respiration and circulation. Therefore, an effort should be made to minimize alterations in intrathoracic pressure. Further investigation is necessary to clarify the details of the mechanisms by which moderate mediastinal displacement causes alterations in cardiocirculatory function.

Experimental work on dogs has little application to the problem under discussion. Because of different anatomic and physiologic arrangements in the canine, the remaining lung may be hyperinflated to fill the major portion of the thoracic cage immediately after pneumonectomy without causing any significant disturbance.

In this communication, the position of the mediastinum has been stressed. Reference has not been made to the detrimental effects of a positive intrapleural pressure itself aside from its influence on the position of the mediastinum. In referring to circulatory changes associated with mediastinal displacement, the effect of the intrapleural pressure on the great veins and heart is included. Unless the mediastinum has been fixed by an inflammatory process, the position of the mediastinum is an approximate index of the intrapleural pressure after pneumonectomy. It is not a sufficiently accurate indicator of the pleural pressure, however, to be relied upon just after operation. Small amounts of air may cause a considerable alteration in the intrapleural pressure. Immediately postoperatively the intrapleural pressure should always be determined by manometer readings and the pressure should be adjusted to a slightly subatmospheric level.

#### CONCLUSIONS

Mediastinal displacement in the early postoperative period after pneumonectomy may cause disturbance of the cardiocirculatory and pulmonary function. The clinical significance of a given degree of

mediastinal deviation is greatly influenced by the preoperative cardiopulmonary function and the postoperative condition of the patient. The position of the mediastinal partition and the intrapleural pressure should be carefully adjusted in the postoperative period.

## REFERENCES

1. Cournand, A., and Berry, F. B.: The Effects of Pneumonectomy Upon Cardiopulmonary Function in Adult Patients, *Ann. Surg.* 116: 532, 1942.
2. Lester, C. W., Cournand, A., and Riley, R. L.: Pulmonary Function After Pneumonectomy in Children, *J. Thoracic Surg.* 11: 529, 1942.
3. Maier, H. C., and Cournand, A.: Studies of the Arterial Oxygen Saturation in the Postoperative Period After Pulmonary Resection, *SURGERY* 13: 199, 1943.

## ROENTGENOGRAPHIC DIAGNOSIS OF TORSIONAL DEFORMITIES IN TUBULAR BONES

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**I**N THE roentgenographic diagnosis of the relative positions of the upper and lower extremities of long bones, three types of displacement may be recognized; (1) angulational, (2) translational, and (3) rotational or axial.

The first, characterized by angulation of the longitudinal axes of the opposite ends, is readily recognized on anteroposterior or lateral roentgenograms as a typical valgus, varus or bowing deformity. The second, characterized by parallel displacement of their respective axes, is similarly easily identified on routine roentgenograms taken at right angles. The third, or rotational displacement, often presents the utmost diagnostic difficulty, although its recognition is not infrequently of primary importance in establishing the indications for treatment. This is true in the treatment of fractures, recent or malunited, of anteversion of the femoral neck, of coxa anteverta, of resistant cases of clubfoot, and other conditions.

Commonly, the determination of rotational displacement depends upon exposure of the whole bone to roentgen beams which diverge from each other by known angular amounts. This method affords an excellent opportunity for the scientific measurement of the degree of rotation of a known anatomic prominence such as the femoral neck. However, this method is not always conveniently applicable, particularly when there has been a loss of continuity in the shaft of the bone. From a practical point of view, it is seldom, if ever, necessary to determine the degree of such rotations with mathematical precision, provided its direction can with accuracy be demonstrated. In this endeavor, a few simple observations have been found very helpful.

In recent fractures the presence of rotation of one fragment upon the other around a longitudinal axis must be envisaged when a disproportion persists between the fracture ends (Fig. 1). In the absence of any marked telescoping of the bone ends, this appearance can arise only from a rotational displacement, since long bones are, in general, irregularly polygonal or elliptical, but almost never truly circular in outline. As a consequence, the magnitude of their diameters or transverse axes will vary so that it is possible to define a largest or major axis and a smallest or minor axis. Anatomic reduction must, of course, include restoration of length, re-establishment of longitudinal alignment, and control of rotation, so that the major axis of one fragment coincides with the major axis of the other fragment. Provided the first two con-



ditions are satisfied, any steplike or cross-sectional disproportion between the transverse axes at the site of a fracture necessarily indicates that a small diameter of one fragment has been juxtaposed to a long diameter of the other fragment and that, therefore, rotation has not been corrected.



Fig. 1.—Anteroposterior and lateral views of a femur in which fracture of the lower third has been produced by osteotomy. The lower fragment has been rotated 90 degrees in relation to the upper. The longitudinal alignment is excellent, but the steplike disproportion in diameter at the site of osteotomy betrays the rotational displacement.

Failure to recognize the presence of rotation may account in no small measure for the difficulty experienced in the treatment of spiral or malleolar fractures of the tibia, fractures of the femoral neck, and especially supracondylar fractures of the humerus. In the latter case, the thinness of the bone in the supracondylar region makes the retention of end-to-end reduction most precarious and it is probably because of the persistence of some rotation that more marked displacement can be avoided. On the other hand, recognition of the situation is a clear indication to desist from any manipulative efforts other than those designed to correct excessive rotational deformity.

In Fig. 2 *A*, an osteotomy simulating a supracondylar fracture has been produced and the lower end has been rotated externally. On the anteroposterior view an excellent reduction seems to have been accomplished, but the lateral view discloses what might be mistakenly considered a posterior displacement of the upper fragment. However, any

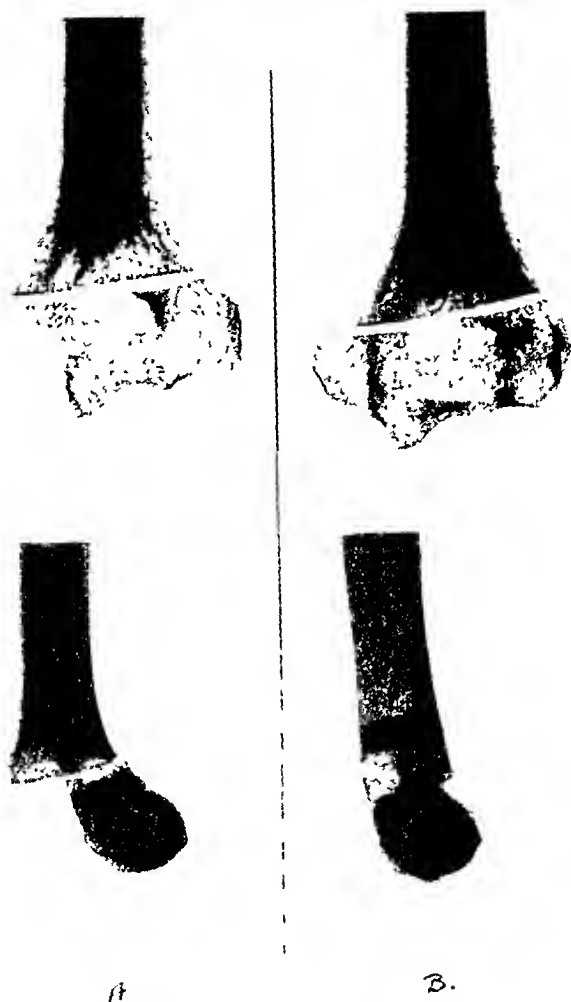


Fig. 2.—*A*, Supracondylar osteotomy, external rotation of distal fragment; anteroposterior alignment excellent. Lateral view shows what appears to be posterior projection of the upper fragment. *B*, Anteroposterior view showing what appears to be excessive medial displacement of the lower fragment, but produced as a result of internal rotation alone. Both are betrayed by cross-sectional disproportion.

effort to displace either fragment in an anteroposterior plane would be valueless and might be harmful. From the bony disproportion, with a posterior step existing at the fracture site, it is evident that only internal rotation of the lower fragment will suffice to correct the malalignment. Similarly, in Fig. 2 *B*, the appearance of a disproportion on the anteroposterior view indicates the presence of internal rotation, rather than excessive medial displacement of the lower fragment.

Although the existence of rotation can, with assurance, be established by the presence of such "cross-sectional incongruence," the direction of rotation can only be determined by other observations. These are based upon the principle which has already become familiar in the roentgenographic estimation of the angle of anteversion of the femoral neck. Essentially, the principle here utilized is that of determining the projection relationships between two transverse axes, which normally converge at known angles. In the case of the femur, these are the bicondylar axis and the axis of the femoral neck. A haphazard view of a foreshortened neck of the femur would give no valid information by which rotation of the femur as a whole could be differentiated from torsion within the course of the femur. However, if it were specifically stated that the knee was directed forward in a standard roentgenographic position and that, consequently, the bicondylar axis was transverse, the appearance of the upper end of the femur would immediately become of diagnostic significance. Combined with a capital shadow and a foreshortened lesser trochanter, the foreshortening of the femoral neck would justify the assumption of an internal torsion, such as is seen in congenital dislocation of the hip. Combined with a subcapital shadow and an enlarged lesser trochanter, it would justify the assumption of external rotation, such as is seen in *coxa anteverta*.<sup>1, 2</sup>

Using the direction of any normal bony projection as an axis of reference, the same method for the determination of torsion can be applied to all the long bones. Once the normal angular relationship of the prominence to any other transverse axis is known, torsion existing between the two axes can be roentgenographically established and, if necessary, readily measured. However, it is essential that the whole bone be radiographed on a single plate. Unless both axes of reference are projected on the same roentgen plate, it is impossible to draw anything but inference as to the presence or direction of any existent torsional deformity. The ease with which torsional deformities can be visualized will, of course, depend upon the length of the transverse axis used for reference.

In the humerus, the lower or bicondylar axis is preferable to the upper axis, because of the shortness of the humeral neck. In the humerus, in direct contrast to the femur, the axis of the head and neck is retroverted and makes a backward and inward opening angle of about 20 degrees. On the anteroposterior view, the bicondylar axis presents its greatest projection, but the head and neck are foreshortened (Fig. 3, *A* and *B*). An oblique view, taken with the humerus in 20 degrees of external rotation, shows the longest profile of the head and neck, but the bicondylar axis appears foreshortened (Fig. 3 *C*). It is only when the lower half of the osteotomized humerus is rotated internally through an angle of 20 degrees that both the axis of the neck and the bicondylar axis become parallel and simultaneously project at their greatest length (Fig. 3 *D*).

Because of the great range of motion possible at the shoulder joint, even marked torsional changes may be easily compensated without attracting any special attention. In the forearm, however, this is not the case. Here much slighter torsional deformities may lead to noticeable limitation of pronation and supination, and it may become a matter of prime importance to differentiate between limitation of motion due to soft tissue contracture, to joint pathology, or to torsional changes in either of the forearm bones. Fortunately, the normal presence of lateral projections on each of the forearm bones permits recognition of torsional changes with comparative ease.



Fig 3—A and B, Normal humerus anteroposterior and lateral views. The head and neck project posteriorly and medially. C, 20 degrees external rotation; the neck is seen in maximum profile, but the bicondylar axis is foreshortened. D, Osteotomy and 20 degrees internal rotation of lower end, both the bicondylar axis and the axis of the neck are seen in maximum profile. Note step formation at side of osteotomy, indicating cross-sectional disproportion.

Examination of the ulna discloses that in its anatomic position the coronoid process points almost directly forward, while the styloid process, at its distal end, points almost directly backward. Its bony projections are best seen on lateral view and largely disappear on anteroposterior view. This is clearly visualized on the lateral roentgenogram of the ulna (Fig. 4 A). The forward projecting coronoid process and

the backward projecting styloid process are both seen in profile. On the anteroposterior view (Fig. 4 *B*), the coronoid and styloid process both become foreshortened and are hidden from view, beneath the shadow of the long axis of the bone. When the bone is osteotomized and the lower end rotated through 90 degrees, combination pictures are obtained. On the lateral view (Fig. 4 *C*) the coronoid process is seen as in the normal, but the styloid process assumes the position characteristic of its normal anteroposterior view. On the anteroposterior view (Fig. 4 *D*) the styloid process assumes the position characteristic of its normal



Fig. 4.—A, Normal ulna, lateral view. The coronoid process projects forward, the styloid process projects backward; both are seen in profile. B, Normal ulna, anteroposterior view. Both the coronoid process and the styloid process are foreshortened and are largely hidden in the shadow of the long axis of the bone. C, Lateral view of twisted ulna. The lower end of the ulna has been rotated 90 degrees after osteotomy; at its upper end the coronoid process presents its normal forward projection. The styloid process, however, is hidden and presents the appearance typical of a normal anteroposterior exposure. D, Anteroposterior view of twisted ulna; at its upper end the coronoid process is hidden, but the styloid process presents the appearance characteristic of a lateral exposure.

lateral exposure, while the coronoid presents its normal anteroposterior appearance. It follows, therefore, that the clear outline of the styloid process on a routine anteroposterior view and its absence on a routine lateral view are pathognomonic of torsion in the ulna.



Fig. 5.—*A*, Normal radius, anteroposterior view: The bicipital tuberosity projects medially, the styloid process projects laterally. *B*, Normal radius, lateral view; both the bicipital tuberosity and the styloid process are foreshortened, so that they are hidden in the shadow of the long axis of the bone. *C*, Anteroposterior view of twisted radius; the upper end presents its normal appearance, but the lower end is typical of a normal lateral view. *D*, Lateral view of twisted radius; the upper end presents its normal appearance, but the lower end is characteristic of a normal anteroposterior view.

In the radius, the situation is exactly opposite. Because of the fact that in the anatomical position the bicipital tuberosity projects medially and the radiol styloid process projects laterally, its projections are best seen on anteroposterior view, while on the lateral view they become minimal. The normal anteroposterior roentgenogram reveals the medial projection of the bicipital tuberosity and the lateral projection of the styloid process (Fig. 5 *A*). On the lateral view, both these processes

tend to disappear (Fig. 5 *B*). As in the ulna, the anteroposterior view, following rotation osteotomy, yields combination pictures. The anteroposterior view discloses a normal upper end, while the lower end is typical of a normal lateral roentgenogram (Fig. 5 *C*). The lateral view discloses a normal lateral view of the upper end with a normal anteroposterior view of the lower end (Fig. 5 *D*). The absence of the radial styloid process in a routine anteroposterior view and its presence on a routine lateral view are pathognomonic of torsion in the radius.

Normally, the radial styloid will best be visualized in the position in which the bicipital tuberosity is seen at its maximum. Similarly, the ulnar styloid will be seen at its maximum in the position in which the coronoid makes its longest projection. These facts make the determination of a torsional deformity possible, regardless of the relative positions of the bones at the time the roentgenogram is made. In complete supination, an anteroposterior view of the forearm will disclose both radial prominences and neither ulnar prominence, while on the lateral view the reverse situation will be seen. In midpronation (90 degrees), the anteroposterior view will disclose the normal anteroposterior view of the ulna, with a normal lateral view of the radius. In consequence, none of the four bony projections will be seen normally. However, on the lateral view (Fig. 6), all four projections will be visualized. The significance of this observation in the prevention of malunion is apparent and is well illustrated in the following case.

John M., aged 25 years, was referred for the diagnosis of a left forearm deformity: difficulty in turning his palm upward. This had developed after an injury at the age of 10. The patient did not know exactly what had happened, but he believed he had suffered a fracture, because his arm was in plaster for about a month.

Examination disclosed a fairly straight forearm, with what appeared to be an increase in the carrying angle. Flexion and extension were completely normal. Pronation could be performed to 50 degrees from the neutral position, but supination was possible to only 10 degrees beyond the neutral. The wrist and finger motions were normal. There was no evidence of motor or sensory disturbance in the hand or fingers.

Clinically, it was impossible to establish whether the limitation of supination was due to a pronation contracture, to disturbance at either radio-ulnar joint, or to some intrinsic bone change. In this dilemma, the roentgenogram necessarily taken in the flexed neutral position and not in the standard position, proved most enlightening (Fig. 7). The appearance of the upper ends of both radius and ulna on the anteroposterior and lateral views was quite normal. The fact that the radius was able to assume its normal supination position established the fact that the clinical limitation of supination was not arthrogenic or myogenic in origin. The appearance of the lower end, however, was most interesting. The ulnar styloid presented its normal appearance on both anteroposterior and lateral views. The radial styloid, on the other hand, presented its normal anteroposterior appearance on what was clearly a lateral view of the radial tuberosity and its normal lateral appearance on what was an anteroposterior view of the upper end. Apart from the bowing and disproportion in length, the radius was obviously the site of a marked pronation of the lower end in relation to its upper end.

In retrospect, it seemed justifiable to conclude that this patient had suffered a fracture of one or both bones of the forearm. The ulna, either unbroken or anatomically reduced, displayed its normal roentgenographic appearances. The lower end of the radius, however, was obviously reduced and fixed in relative pronation, while its upper end remained in supination. Although the longitudinal alignment was fairly satisfactory, the internal torsion of the lower radial portion resulted in inability to turn the palm upward, because the normal limitation of supination at the upper end prevented any compensating correction of the malalignment. Rotation osteotomy of the radius was advised, but has not yet been undertaken.

In the leg, because of the absence of prominent lateral projections, the roentgenographic recognition of torsion is somewhat more difficult. The

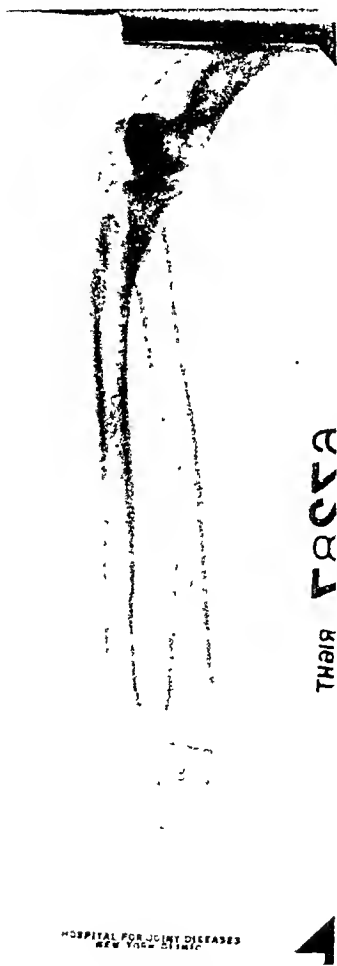


Fig. 6.

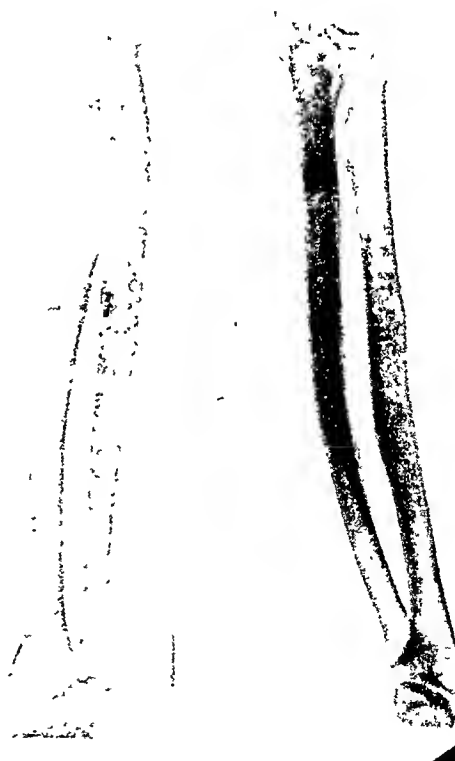


Fig. 7.

Fig. 6.—Lateral view of normal forearm in midpronation. All four prominences are readily recognized. In full supination the radial prominences would disappear.

Fig. 7.—John M. On the lateral view of the forearm the ulna presents its normal lateral appearance. The radius presents a combination form, the bicipital tuberosity posterior appearance. On the anteroposterior view of the forearm, the ulna presents its normal anteroposterior appearance. The upper end of the radius presents its normal anteroposterior appearance, but its lower end is typical of a normal lateral view, indicating a torsional deformity in the radius.



medial projection of the internal malleolus is so slight as to make it practically valueless for establishing an axis of comparison with the bicondylar axis of the tibia. However, the method here described can be employed with slight modification. The fixation of the fibula to the tibia justifies consideration of the external malleolus as a prominence on the lower end of the tibia. On a true lateral view, with the axis of



Fig. 8.—A, Lateral view of tibia and fibula; The axis of the fibula and the external malleolus lies just at the posterior margin of the tibia. B, Lateral view of osteotomized fibula and tibia. (Although not absolutely identical, the upper end of the tibia is essentially in the same position as in A.) The lower end of the tibia has been rotated internally. As a consequence, the shadow of this fibula has been displaced forward.

the knee joint perpendicular to the roentgen film, the long axis of the fibula normally lies posterior to the longitudinal axis of the tibia (Fig. 8 A). This is, of course, due to the fact that the bimalleolar axis of the ankle joint is normally externally rotated 20 to 25 degrees from the bicondylar axis of the tibia. Using this relationship as a norm, it will be seen that external torsion of the tibia serves to increase the apparent

backward displacement of the fibula on the lateral roentgenogram of the tibia. Internal torsion, on the other hand, results in a relative forward displacement of the malleolar shadow on the lateral view of the tibia (Fig. 8 B). The demonstration of this phenomenon, however, depends upon securing an absolutely true lateral view of the upper end of the tibia, as a norm, against which comparison may be made. Rotation of the upper end in either direction will, of course, result in a corresponding loss of relative movement of the fibular shadow in the opposite direction.

#### SUMMARY

The ends of a long bone may be displaced either along their longitudinal axis, across this axis, or around this axis. The determination of rotational or torsional displacements is more difficult and can only be made if special data is noted. Such data can be obtained by a study of the roentgenographic projections of normal prominences on the long bones. In the long bones of the four extremities, the presence of the normal anatomic prominence is noted and their roentgenographic appearance in critical positions is illustrated.

#### REFERENCES

1. Milch, Henry: Epiphyseal Coxa Anteverta, *J. Bone & Joint Surg.* 19: 97, 1937.
2. Milch, Henry: Coxa Anteverta Versus Anteversion of the Femoral Neck, *Bull. Hosp. Joint Dis.* 4: 79, 1943.

## DERMA-FAT-FASCIA TRANSPLANTS USED IN BUILDING UP THE BREASTS

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**B**UILDING up the contour of the breast after loss due to abscess, trauma, amputation, or faulty development can be accomplished successfully. In young and middle-aged women, complete or partial loss of a breast (see Figs. 1 and 2) produces a psychic effect on the individual and in many cases is a hindrance to their social and economic welfare, and, therefore, should be accorded considerable attention in reconstructive surgery. To produce a firm, symmetrical, and esthetic contour of the deformed breast, I have modified the technique by the use of the derma-fat-fascia transplantation.

### OPERATION

Before the reconstruction is undertaken, the traumatic area must be free from any infection and completely healed. The recipient and donor areas are aseptically prepared and draped. A general anesthesia is preferable. A pattern is made over the existing normal breast to determine the amount of fat necessary to build up the contour of the deformed side. The amount of the fat transplant should be only slightly larger than the amount necessary to allow for the absorption. The site of the donor area is chosen from the lateral section of the gluteal region in order to obtain the necessary depth of the fat graft and the resulting scar will be covered by even scanty bathing costumes.

The pocket for the implant is made over the existing scar if there is one present from a previous operation. If not, the incision is made in the location of the inframammary fold. The skin, with the nipple attached, is extensively undermined to form a pocket large enough to receive the graft without tension. Hemorrhage must be controlled since the formation of a hematoma will cause a loss of the graft. Hemostasis is best effected by pressure with hot wet packs. These packs are left in situ while the graft is removed from the donor area. To lessen the operative time, an assistant can prepare the recipient area while the graft is removed at the same time.

The fat graft must be removed with a section of the derma and fascia intact. The pattern of the approximate amount of fat to be removed is marked over the donor area. The section of the derma to be left intact is outlined with a dye within that pattern. The epithelium is excised from that outlined section, the dermatome being used preferably to re-

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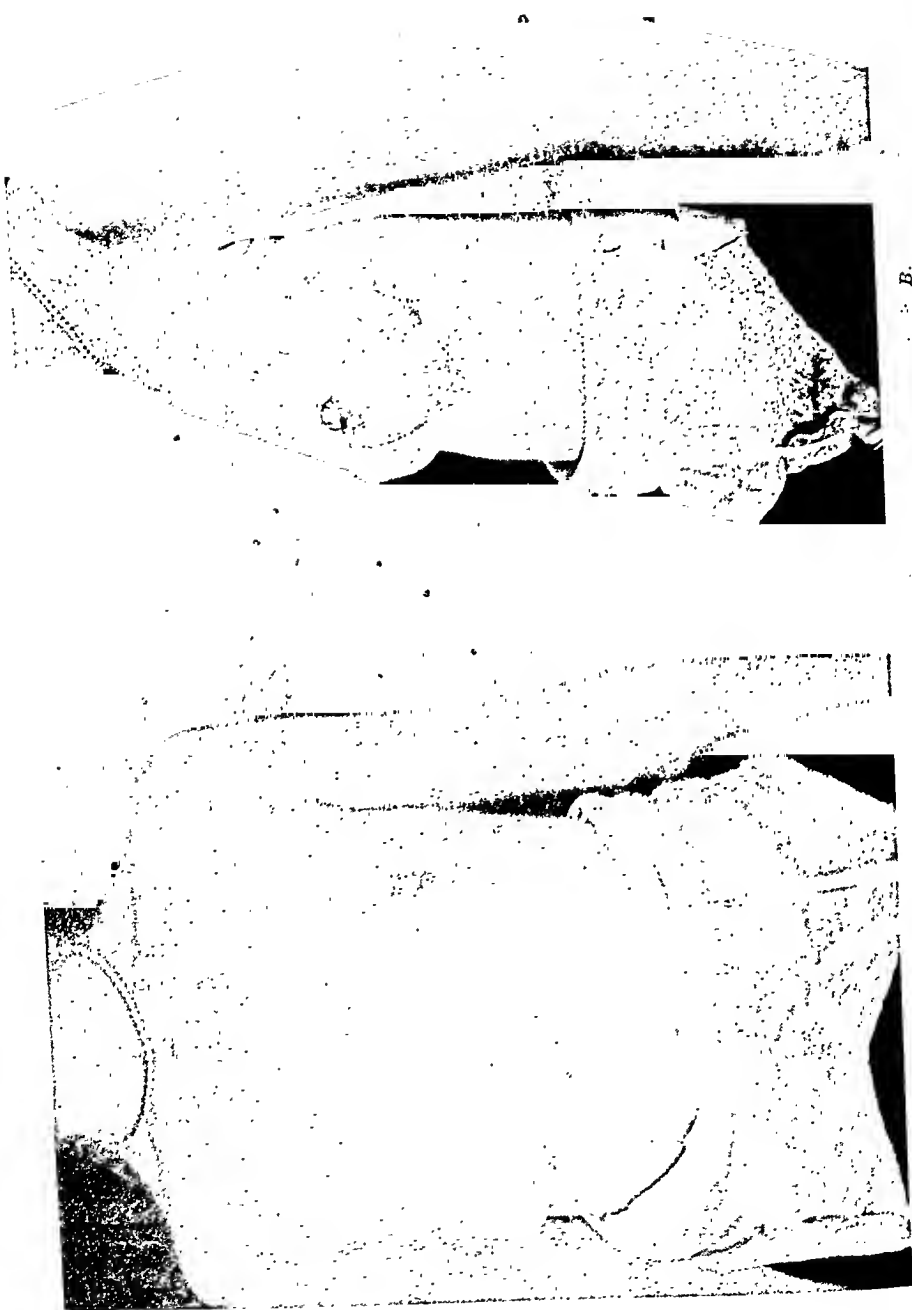


Fig. 1.—A, Complete absence of breast tissue following removal of benign tumor. B, Corrected by derma-fat-fascia transplant inserted in a pocket made over the existing scar.



Fig 2—A, Deformed breast with adherent scar and loss of 1/3 of its tissue resulting in asymmetry of breasts. B, Scar excised, skin extensively undermined, and derma-fat-fascia graft implanted.

move it. In using the dermatome, the cement should be applied to the drum over a space similar in size to the outlined section of epithelium to be removed. The epithelium can also be excised with a sharp blade by applying traction over the skin.

Oblique incisions are then made along the outer margins of the de-epithelized area, deep through the base of the fat, to and including the layer of fascia so that the base has twice the area of the dermal region. The section of fat covered by derma and attached to the underlying

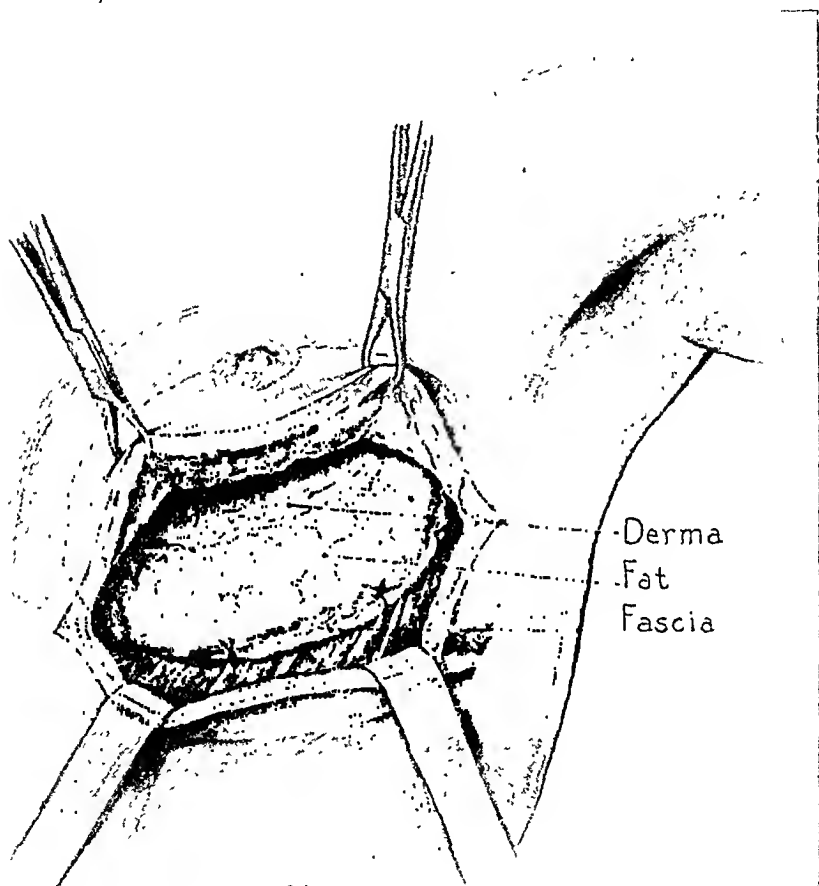


Fig. 3.—Diagram showing the position of the derma-fat-fascia graft.

fascia is gently cleared for the required distance by blunt dissection and the appropriate sized derma-fat-fascia graft is stripped from the underlying muscle in one section, since several sections will have a greater absorption tendency and will undergo more degeneration than a single large piece. Catgut anchor sutures are inserted at each end of the graft through the fat and derma. Hemorrhage in the donor area is controlled and the margins of the surrounding fat are undermined and approximated with catgut sutures so that the cavity is closed to obliterate dead spaces created by the removal of the graft. The skin margins are

approximated with fine interrupted silk sutures and a pressure dressing is applied.

The gauze pads are removed from the previously prepared pocket, which must be absolutely dry, and the fat graft held by the anchor sutures is introduced with as little handling as possible into the cavity and placed with the derma outermost directly under the flap of the skin (see Fig. 3), and anchored by the anchor sutures which are made to emerge through the skin at the distal ends of the pocket. The base of the

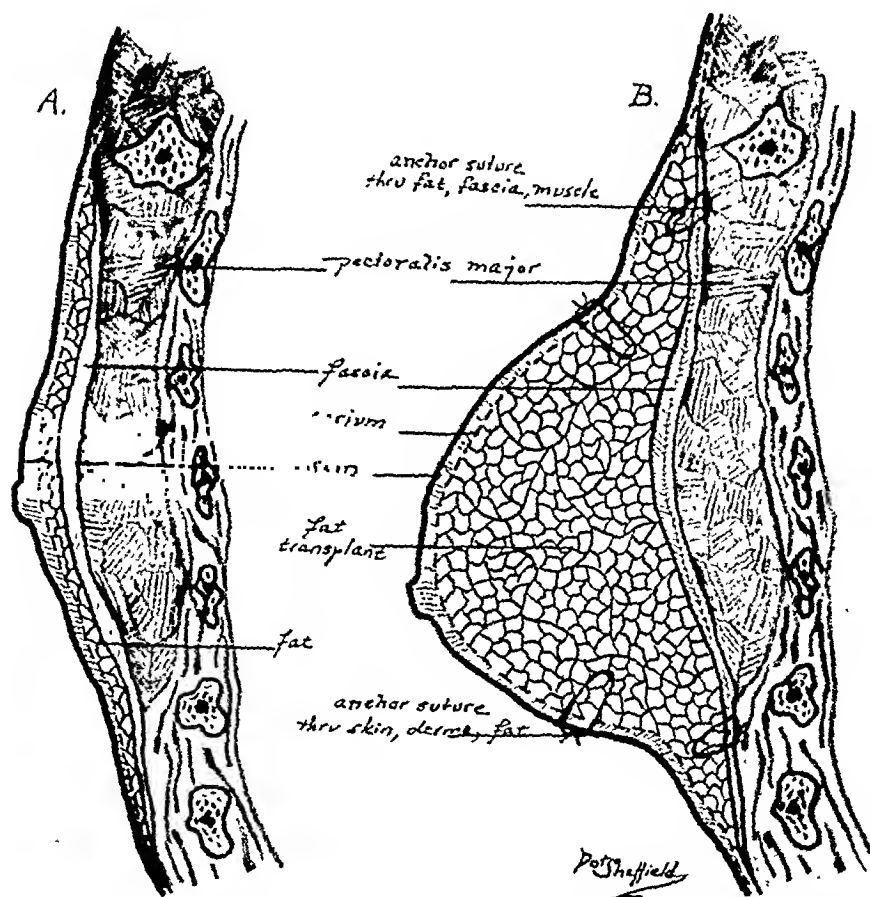


Fig. 4.—A, Sagittal section of deformed breast showing absence of breast tissue. B, Sagittal section of same breast showing derma-fat-fascia transplant anchored in place.

fat containing the fascia is curled and shaped to the desired roundness and is anchored to the fascia and muscles at the base of the chest (see Fig. 4). With the graft in place, the incision in the skin is closed accurately with fine interrupted silk sutures, drainage being omitted.

The dressing, consisting of large pieces of gauze, is placed around the base of the rebuilt breast thus producing an elevation at the center of

the breast with the pressure at the base. The patient must be taught to maintain immobility of the entire pectoral region for one week, at the end of which time the sutures are removed.

#### SUMMARY

I have found that a fat graft covered by a layer of derma on one side and fascia as its base will attach itself more firmly to the recipient base. Since this type of graft is easily invaded by capillaries, there is an increase in the vitality of the fat tissue and a tendency to regenerate most satisfactorily. This method reduces greatly the amount of absorption of the fat and renders the graft more resistant to infection. A derma-fat-fascia graft is more easily handled, gives better contour to the breast, and produces a firmer filler substance. Fat grafts without the attachment of the derma and fascia absorb at least from one-third to one-half of their volume. This method is more satisfactory than the pedicle flap method of rebuilding the contour of the breast as it eliminates extra stages of operation, unnecessary scarring, and the resulting contour is more esthetic.

Similar derma-fat-fascia transplants can be used in many other conditions such as depressions in the facial contours, depressed frontal areas, destroyed lower lips, and burns about the face. This method can also be used in transplantations around joints, brain and bone defects, and contractures around the hand. In these cases where the depressions are shallow, the derma-fat-fascia grafts can be acquired from the abdomen or thigh since the thickness of the fat in these areas corresponds more closely to the amount required in filling shallow depressions.

#### REFERENCES

- Binnie, J. F.: Some Uses of Fat in Surgery, *Surg., Gynec. & Obst.* 18: 336, 1914.  
 Davis, J. S., and Traut, H. F.: Plastic Surgery. Dean Lewis' Practice of Surgery, Vol. 5, Hagerstown, Md., 1930, W. F. Prior Company, Inc.  
 Douglas, J.: Fat Transplant for Adhesions After Tenorrhaphy, *Ann. Surg.* 71: 791, 1920.  
 Gillies, H. D.: Plastic Surgery of the Face, London, 1920, Oxford University Press.  
 Gurney, C. E.: Experimental Study of the Behavior of Free Fat Transplants, *SURGERY* 3: 679, 1938.  
 Kanavel, A. B.: The Transplantation of Free Flaps of Fat, *Surg., Gynec. & Obst.* 23: 163-176, 1916.  
 Kanavel, A. B.: The Transplantation of Free Flaps of Fat, *Tr. Am. S. A.* 34: 434-465, 1916.  
 Kanavel, A. B.: Transplantation of Fat, Fascia, and Living Tissue in Surgery. A Report of Experiences in Various Conditions, *J. Missouri M. A.* 14: 333-340, 1917.  
 Key, B. W.: Fat Implantations, *Arch. Ophth.* 48: 292, 1919.  
 Kirschner, M.: Über freie Sehnen- und Faszientransplantation, *Beitr. z. klin. Chir.* 65: 472-503, 1909.  
 Lexer, E.: Zwanzig Jahre Transplantationsforschung in der Chirurgie, *Arch. f. klin. Chir.* 138: 251, 1925.  
 Roy, J. N.: War Surgery: Plastic Operations on the Face by Means of Fat Grafts, *Laryngoscope* 31: 65-77, 1921.



## AN IMPROVED CUTTING EDGE FOR THE PADGETT DERMATOME

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IT HAS become increasingly apparent, with the passage of years, that the use of free grafts of split sheets of skin of varying thickness has a most important place in the plastic repair of skin defects. Concomitant with the steady increase in the field of applicability of these types of skin grafts there have been developed a number of dermatomes which permit the accurate cutting of large split-skin grafts of suitable size and of uniform and desired thickness. Indeed these dermatomes have to a certain extent been responsible for the extended utility of the various types of split grafts.

The dermatome described by Padgett<sup>1</sup> has become widely used because of the ease with which its use is mastered and because of its dependability. It consists of a drum which is fixed to the skin with glue and to which is attached a movable knife blade which can be fixed at a definite measured distance from the drum, thus insuring the cutting of a sheet of skin of the desired thickness. It has enabled many surgeons to cut suitable grafts who were unable to do so with free plastic knives. In my hands its sole disadvantage has been the difficulty of keeping the blades sharp. This is especially a problem in rural areas and in army hospitals where facilities are not available for expert sharpening of knives. The dermatome presented by Poth<sup>2</sup> consists of a traction bar and needle retractors for maintaining uniform skin tension, and of a frame which carries a cutting edge and contains a mechanism for regulating the depth of cut. It yields most satisfactory results. Perhaps the most novel and useful feature of this dermatome is the cutting edge which consists of four safety razor blades fixed end to end in a holder. This insures a sharp knife which can be assembled anew for each use and eliminates the problem of dull blades and of efforts to sharpen them.

As I had used with satisfaction both the Padgett and the Poth dermatomes, it occurred to me that the utility of the former could be increased by incorporating the principle of the latter of using a series of safety razor blades in place of a formed plastic knife. Consequently, a very simple blade carrier was devised which can be used in place of the regular knife.

The regular knife is 16.3 cm. long and 2.5 cm. wide. At either end is a slot which fits over a pin attached to the arm of the drum. It is held in place by a metal cuff which fits over the frame and a portion of the blade. The new carrier (Fig. 1) is roughly the same size, shape, and thickness. It is 2.2 cm. in width. On one surface a depression is ground

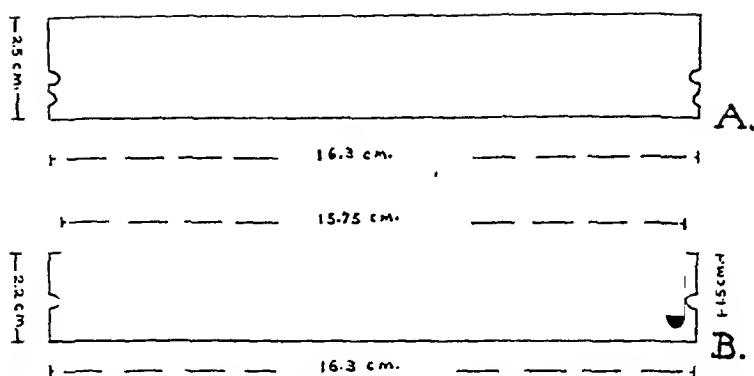


Fig. 1.—The dimensions of the regular knife (A) and of the blade carrier (B).

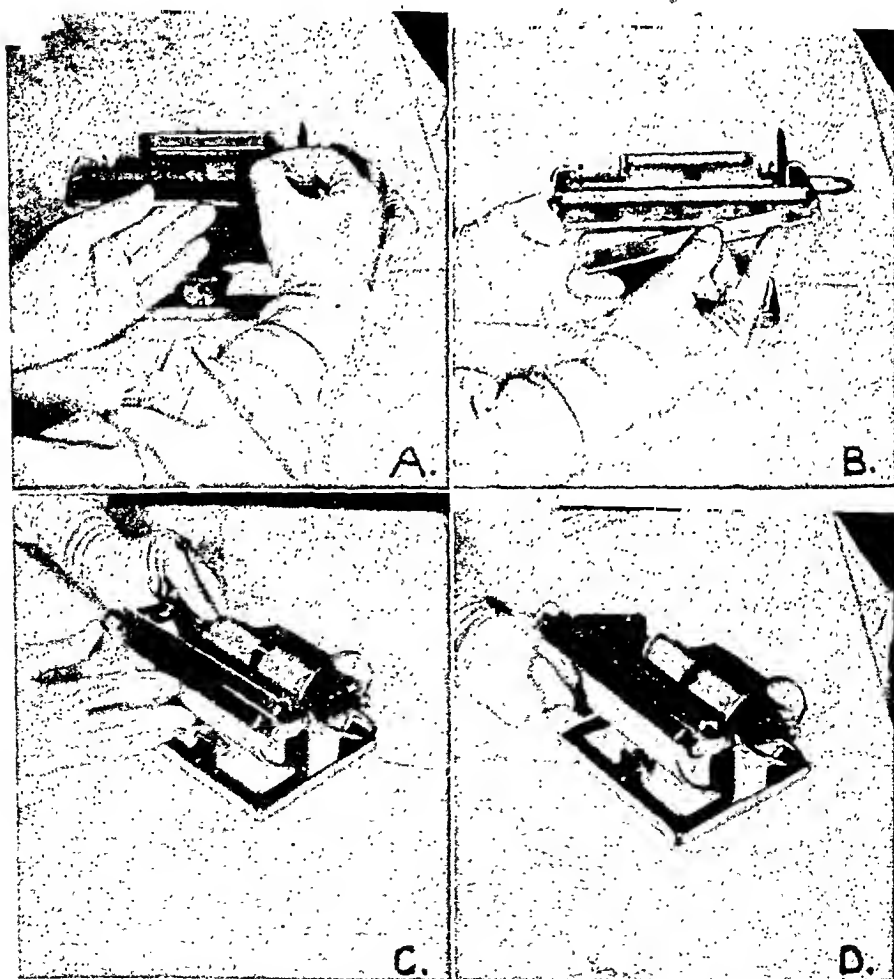


Fig. 2.—The assembling of the cutting edge. A, The blade carrier is in place and the razor blades are being slipped into position. B, and C, The razor blades are in position and the cuff is being placed over frame and carrier. D, The assembled cutting edge.

which is 15.75 cm. long, 1.5 cm. wide, and 0.2 mm. (8/1,000 inch) in depth. This depression is just long enough to permit four Valet razor blades to lie end to end within it. The razor blades are 1.8 cm. in width so that when placed properly in the depression their edge protrudes 0.3 cm. beyond the edge of the carrier, thus making the assembled cutting edge and carrier the same width as that of the regular knife. The razor blades are 0.25 mm. (10/1,000 inch) in thickness so that when they lie in place they rise 0.05 mm. (2/1,000 inch) above the surface of the carrier. When the carrier and metal cuff are in position the blades are held firmly in place between the carrier and the frame.

The dermatome and blade carrier are sterilized in the usual manner. The razor blades are cleansed carefully with ether and placed in some cold sterilizing solution. Before being used they are rinsed with saline solution or aqueous zephiran. The operator places the blade carrier on the frame and holds it firmly in place with the thumb and index finger of one hand (Fig. 2). With the other hand the four razor blades are slipped into place end to end in the slot between the carrier and frame. Care is taken to have the same surface of each blade up as the bevel is slightly different on the two surfaces of the razor blades. When they are placed properly the metal cuff is put on without difficulty. The entire manipulation takes only a moment.

This cutting edge has proved entirely reliable. It permits one to have with negligible expense a new sharp blade for each use of the dermatome.

#### SUMMARY

1. A new blade carrier is described for use with the Padgett dermatome which is easily constructed with little expense. It utilizes a series of safety razor blades in place of the regular knife, and makes possible a new sharp cutting edge for each use of the dermatome.

The author wishes to express his appreciation to Chief Machinist's Mate Emil J. Abrisch, U. S. N., who constructed the first blade carrier for him.

#### REFERENCES

1. Padgett, E. C.: Calibrated Intermediate Skin Grafts, Surg., Gynec. & Obst. 69: 779-793, 1939.
2. Poth, E. J.: A New Technique for Cutting Skin Grafts Including Description of New Instruments, SURGERY 6: 935-939, 1939.

## OBSERVATIONS ON THE INTRACISTERNAL INJECTION OF POTASSIUM PHOSPHATE IN THE DOG

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THE physiologic responses to intraventricular injection of pituitrin and pilocarpine have been experimentally studied by Cushing.<sup>1</sup> Other investigators<sup>2</sup> had demonstrated that certain substances such as dyes, toxins, and neurotropic viruses produced no effect when injected into the blood stream, whereas when injected intracerebrally, intrathecally, and intraventricularly, active responses were obtained. The experimental evidence indicates that there is a "blood-brain barrier" and that this barrier is mediated through the capillaries of the central nervous system which are endowed with a selective permeability.

The recent work of Stern<sup>3, 4, 5</sup> on the direct action of potassium phosphate on the vegetative centers by intraventricular or intracisternal injection suggested their use in shock. By the single injection of small amounts of potassium phosphate into the cisterna magna, she and Chvoles<sup>6</sup> were able to bring the animal out of shock even when the shock was due to loss of blood. The resulting elevation of arterial pressure is attributed to the direct stimulation of the sympathetic centers by the potassium and depression of the parasympathetic centers through the decrease in ionization of the calcium by the phosphate ion. Favorable results in clinical studies on the battlefield were also obtained by the cisternal injection of 1 to 2 c.c. of the solution.

These encouraging reports suggested the possible use of potassium phosphate in restoring low blood pressures encountered during neurosurgical procedures where entry into the ventricles could be easily effected. The purpose of this study was to determine the action of potassium phosphate under various experimental conditions, especially hemorrhagic shock. The results obtained are the basis for this report.\*

### METHODS

Nine dogs were used, seven of which were subjected to varying degrees of hemorrhage from the femoral artery. Intravenous barbitol anesthesia was employed in all experiments. The technique as outlined by Wiggers and Werle<sup>7</sup> for the production of *irreversible* shock was followed. In each instance in which hemorrhagic shock was produced, the dog was bled from one femoral artery so that a blood pressure level of 50 mm. was maintained for at least one hour and then further lowered to a level of

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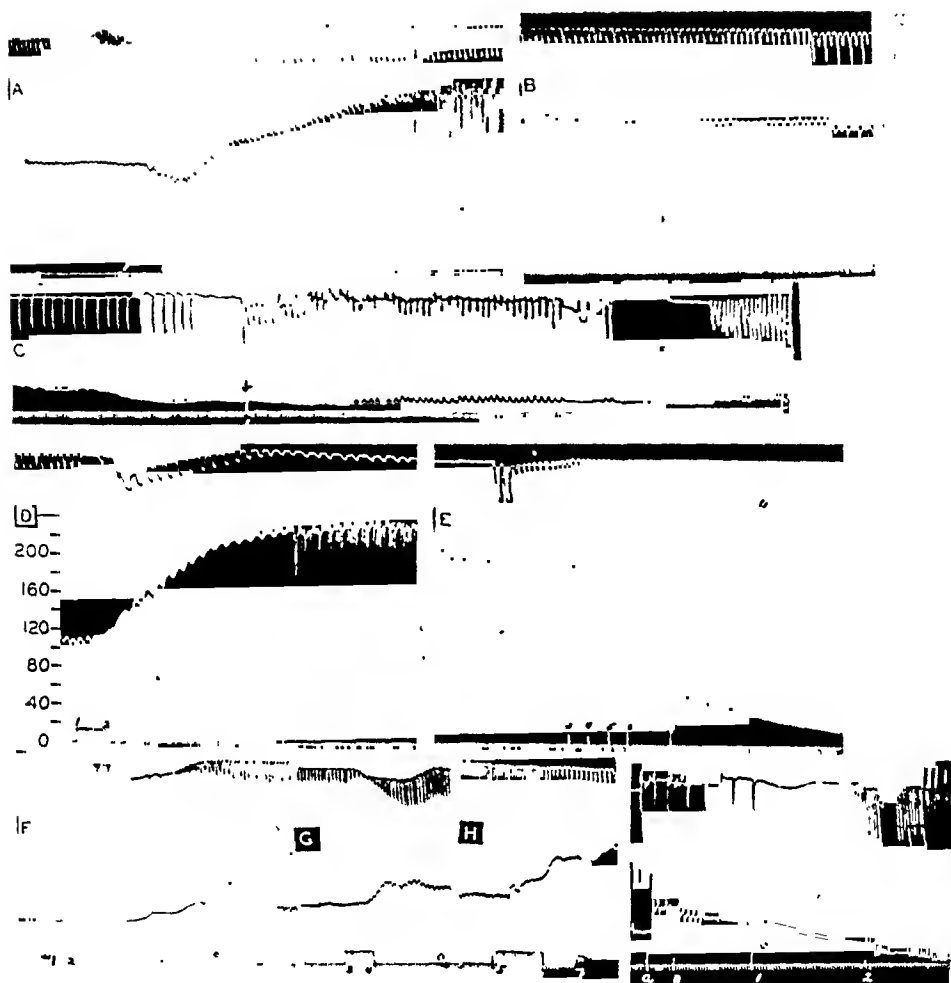


Fig. 1.—A and B. (In all figures the time is marked in seconds on the line of zero blood pressure.) This dog's weight was 15.2 kg., normal blood pressure, 116 mm. Between 1 and 2, 1 c.c. of potassium phosphate was injected intracavernally into an unbled dog. Elapsed time between A and B was 5 minutes.

C. This dog's weight was 6.5 kg. The dog was bled at the rapid rate of 322 c.c. in forty-five minutes. The blood pressure fell to 30 mm. Hg, at which point before the blood could be reinjected, respirations ceased. While artificial respiration was being given, 0.4 c.c. (arrow) of potassium phosphate was injected. There was no effect.

D and E. The dog's weight was 18.6 kg. Potassium phosphate, 2 c.c., was injected intracavernally into the unbled dog. (1 and 2.) The interval between D and E marks four minutes. There was a marked rise in pressure followed by a rapid fall and death due to respiratory and circulatory failure; 3, 4, 5 and 6 represent pauses of the drum for thirty seconds each.

F, G, and H. The dog's weight was 13 kg. This dog was bled rapidly 475 c.c. so that at (1) blood pressure fell to 36 mm. Immediately, without reinjection of blood (as in the Wiggers-Werle technique), 0.5 c.c. of potassium phosphate was injected (1 and 2) and again at (3 and 4) 0.4 c.c. was injected. There was a tendency for the pressure to drop, although only slightly, so at 5 and 6 blood was reinjected and blood pressure rose above normal.

I. The dog's weight was 15.4 kg.; this dog was bled 895 c.c. After having been held at shock levels for three hours the blood was reinjected; a indicates the end of the injection. The blood pressure rose but rapidly slipped. As respiration failed, artificial respiration was begun at b. At (1), 0.4 c.c. of potassium phosphate was injected. At (2), artificial respiration was begun and an additional 0.4 c.c. of potassium phosphate injected.

30 mm. Hg for 30 to 45 minutes. In all of these cases when the full amount of withdrawn blood was reinjected and no sustained rise in blood pressure was produced, the dog was considered to be in shock and the solution of potassium phosphate was then injected intracisternally.

Mean blood pressure was recorded with the mercury manometer from the other femoral artery and respirations by thoracic cage pneumograph and tambour. The solution consisted of  $\frac{1}{6}$  molar (isotonic) solution of potassium phosphate (mixture of  $\text{KH}_2\text{PO}_4$  and  $\text{K}_2\text{HPO}_4$  brought to pH 7.6) as prepared by Stern.<sup>4,5</sup> It was injected by cisternal needle with the dog's head in a lateral dependent position. Stern<sup>4,5</sup> recommended 1 to 2 c.c. as the therapeutic dose for a 70 to 75 kg. man. Calculated on this basis, 0.4 to 0.5 c.c. was considered therapeutic for the 15 to 18 kg. dog. The amount of blood withdrawn varied from 10 to 60 per cent of the estimated blood volume.

#### COMMENT

In Fig. 1, *A* and *B* we obtained a positive response to intracisternal injection of potassium phosphate in a normal dog. There was first an inhibition of respiration and then acceleration. Blood pressure rose so rapidly and vigorously that the record shows carotid sinus slowing of the heart. Fig. 1 *C* is shown to illustrate the negative response obtained when the shock level was maintained according to the technique of Wiggers and Werle. Fig. 1 *D* and *E* demonstrates the sudden collapse after vigorous stimulation when about four times the calculated dose of potassium phosphate is injected. Fig. 1 *F*, *G*, and *H* illustrates the beneficial effect of intracisternal potassium phosphate and blood when the blood pressure is lowered for only a brief time. In Fig. 1, *I*, the blood (895 c.c.) had been reinjected but respiration had failed. Here at a higher level of blood pressure, even though artificial respiration is instituted, potassium phosphate fails to produce a favorable response.

#### DISCUSSION

In reviewing the work of Chvoles,<sup>6</sup> it is interesting to note that in the protocol of his experiment (one illustration), an 11 kg. dog whose initial blood pressure was at a level of 150 mm. was subjected to a fracture of the tibia and withdrawal of 250 c.c. of blood. This dropped the blood pressure to 60 mm. in the forty minutes involved in the procedures. Immediately 1 c.c. of potassium phosphate was injected and the dog manifested improvement which was maintained one hour and fifteen minutes later. The last recorded blood pressure was 170 mm.

This opens the question as to the validity of the criterion of the state of shock. In our experiments the dogs were bled according to the technique of Wiggers and Werle. Only when reinjection of all withdrawn blood failed to produce an effect was the dog considered in shock. Then potassium phosphate was injected intracisternally. Whenever the pres-

sure was above 50 mm. we obtained favorable responses. However, when the animal was in a precarious condition, injection of the phosphate was not only ineffective but apparently dangerous. Large doses (approximating four times the calculated therapeutic dose) resulted in dramatic rise in blood pressure but were followed within a short time by death due to failure of blood pressure and respiration.

The ionic effects of calcium and potassium when injected into muscle, for example, cardiac muscle, and into the peripheral circulation are usually in opposite directions. In general an increase of the K/Ca ratio produces the phenomena of parasympathetic stimulation. The opposite effect is obtained, namely, sympathetic (accelerator) stimulation, when there is an increase of the Ca/K ratio.

There is a reversal of these ionic effects, however, as demonstrated by Stern and co-workers and likewise shown in our experiments, when the potassium salts are injected intracisternally. With potassium phosphate we have obtained tremendous rises in blood pressure in normal animals and acceleration of pulse and respiratory rates. Animals in shock, however, did not respond uniformly. At times there was an increase in pulse rate and blood pressure, but in some instances the action was apparently depressant. In normal animals large doses produced spectacular stimulation which was followed by sudden collapse and death. Certainly the direct central action of potassium phosphate is remarkable. Its exact mode of action is not definitely known.

#### CONCLUSIONS

1. The intracisternal injection of small amounts of potassium phosphate (pH 7.6) in normal dogs stimulates respiration and pulse rate and produces marked elevation of blood pressure.

2. When injected in dogs subjected to hemorrhagic hypotension and shock the result is not uniform.

3. Large doses of potassium phosphate increase respiration, pulse, and blood pressure but may be followed by failure and sudden death.

#### ADDENDUM

In a recent article, C. B. Downman and C. C. Mackenzie (*Lancet* 245: 471, 1943) report the effects of intracisternal potassium phosphate injection in rabbits. These investigators obtained rise of blood pressure, augmented respiration, and increased muscle tone following the injection but they found that these responses were not altered by previous hemorrhage. They obtained no permanent toxic effects following the injection.

I wish to express my thanks to Dr. Ernest Sachs for his interest and to Dr. Joseph Erlanger for his generous suggestions in carrying out this study.

#### REFERENCES

1. Cushing, H.: The Similarity in the Response to Posterior Lobe Extract (Pituitrin) and to Pilocarpine When Injected Into the Cerebral Ventricles, *Proc. Nat. Acad. Sc.* 17: 171, 1931.

2. Friedemann, Ulrich: Blood-Brain Barrier, *Physiol. Rev.* 22: 125, 1942.
3. Stern, L. S.: A propos de la methode d'action directe des substances chimiques sur les centres nerveux, *Schweiz. med. Wchnschr.* 71: 367, 1941.
4. Stern, L. S.: Treatment of Shock by Direct Action on Vegetative Nervous Centers, *Lancet* 243: 572, 1942.
5. Stern, L. S.: Treatment of Shock by Direct Action on Vegetative Nervous Centers, *Brit. M. J.* 2: 538, 1942.
6. Chvoles, G. Y.: Role of the Hemato-Encephalitic Barrier and of the Cerebro-Spinal Fluid in Pathogenesis and Therapy of Shock, *Sovet. vrach. zhur.* 44: 487, 1940.
7. Wiggers, C. J.: The Present Status of the Shock Problem, *Physiol. Rev.* 22: 74, 1942.



# TRAUMATIC PERFORATIONS OF THE SMALL INTESTINE DUE TO NONPENETRATING ABDOMINAL INJURIES

## A SURVEY OF EIGHTEEN CASES

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### INTRODUCTION

PERENNIAL interest in traumatic abdominal injuries has been manifested by the surgeon. In civilian life the automobile, heavy industry, and simple accidents produce innumerable intra-abdominal injuries. The advent of war has increased still further the interest in this subject. Among those organs injured subsequent to blunt trauma to the abdomen is the small bowel. The diagnosis of rupture of the small intestine is very difficult at times. It is hoped that the information gathered and reproduced here will be of assistance in facilitating the diagnosis of small bowel perforations. In those instances where the diagnosis is entertained, early operation will aid greatly in reducing the mortality caused by nonpenetrating trauma to the abdomen.

Traumatic perforations and rents of the small bowel occur when an unexpected blow strikes the abdominal wall. When a blow is received unexpectedly the muscles of the abdominal wall are not contracted. This lack of muscle "splinting" leaves the viscera unprotected and exposed to the full power of an assailing line of force. Therefore the abdominal viscera have little protection against injury under these circumstances. Usually the subcutaneous tissue and the abdominal muscles absorb the shock of blunt trauma, thus diffusing the power of a blow.

When the small intestine becomes the victim of trauma, there are several areas most often involved. These are the fixed segments: the duodenum, near the ligament of Treitz, and near the ileocecal region. When blows to the epigastrium injure the duodenum, the third portion is most frequently affected. This occurs because it is attached to the bodies of the upper lumbar vertebrae by peritoneum. A sudden striking force directed toward the epigastrium will drive the posterior wall of the duodenum against the surface of the vertebral bodies producing an injury to the duodenal wall. Bleeding may occur in some instances. The blood has been known to escape into the retroperitoneal spaces (Case 6). The same general factors produce rents in the vicinity of the ligament of Treitz. A potent force striking a segment of jejunum near this ligament moves the loop beyond its limit of mobility, thus

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CASE NO.	AGE	SEX	HISTORY	DURATION OF INJURY	ADMISSION DIAGNOSIS	X-RAY FINDINGS
1	49	M	Kicked in abdomen during a fight	24 hr. preop.	Perforated abdominal viscus	None taken
2	64	M	Thrown from an auto	6 days before admission	Paralytic ileus, bronchopneumonia, fractured ribs	Pneumonia of the left side, free air under diaphragm
3	38	M	Struck by auto, hematemesis present	12 hr. preop.	Perforated abdominal viscus	Free air present
4	75	M	Struck by auto	7 hr. from injury to death	Shock, multiple contusions, and abrasions	None taken
5	50	M	Kicked in abdomen during a fight	10 hr. preop.	Perforated abdominal viscus	No free air
6	14	M	Struck in epigastrium by handle bars of bicycle, hematemesis present	48 hr. preop.	Possible splenic injury	None taken
7	53	M	Kicked in abdomen during a fight	12 hr. preop.	Possible ruptured urinary bladder	Elevation of right diaphragm, peritoneal irritation noted
8	45	M	Struck by auto while intoxicated, hematemesis present	24 hr. (?) preop.	Indefinite intra-abdominal injury	No free air under the diaphragm
9	15	M	Patient riding bicycle, hit an auto thus driving handle bars into abdomen, hematemesis present	8 hr. preop.	Perforation of hollow viscus	Free air under both halves of diaphragm
10	66	M	Struck by an auto	18 hr. preop.	Perforated abdominal viscus	No free air, fractured pelvis
11	33	F	Kicked in abdomen during a fight	24 hr. preop.	Perforated abdominal viscus	Minimal free air under right diaphragm
12	14	F	Struck in abdomen by handle bars of bicycle while riding, unconsciousness and hematemesis present	5-7 hr. preop.	Perforated abdominal viscus	No free air
13	53	M	Slipped on tile floor falling on abdomen, no vomiting	12 hr. preop.	Perforated abdominal viscus	No free air
14	50 (?)	M	Struck by hit and run driver, unconsciousness, projectile vomiting	Not known	Intracranial injury and shock	Skull fracture

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OPERATIVE FINDINGS	PERITONITIS	ASSOCIATED PATHOLOGY	FINAL OUTCOME	AUTOPSY REVELATIONS
Moderate amount of intestinal fluid, 1½ inch perforation in ileum 18 in. from ileocecal junction	General	Lacerations of scalp	Developed delirium tremens 2 postop., died 5 postop. day	Generalized peritonitis
No operation	General	Fractured ribs and bronchopneumonia	Expired 36 hr. after admiss.	Genl. peritonitis. Two small perforations in ileum 2 ft. from ileocecal valve
Small amount bile-stained fluid in peritoneal cavity, ¼ inch perforation in first portion of duodenum	General	Scalp laceration, fracture nasal bones and humerus, laceration abdominal wall	Expired 4th post-operative day	Generalized peritonitis
No operation	General	Fractured pelvis	Died 7 hr. after injury	3 small perforations in ileum 2 ft. from ileocecal valve, genl. peritonitis
Moderate amount of intestinal fluid, ½ in. laceration ileum 2 ft. from ileocecal junction	General	Multiple abrasions, periorbital ecchymosis	Died 8 hr. after operation	Generalized peritonitis
Contusion of pylorus and duodenum, localized peritonitis suggesting a walled-off perforation not seen	Local	Multiple contusions and retroperitoneal hemorrhage	Died 13th P.O. day	Walled off ¼ in. perforation on post. wall of duodenum, blood from tear in superior pancreaticoduodenal artery
50 c.c. intestinal fluid aspirated, 4 in. laceration in omentum, 2 ft. from ligament Treitz ½ circumference of jejunum torn	General	Ecchymosis of abdominal wall and above pubis, prevesical hematoma	Developed cystitis and wound infection. Discharged 43 days P.O.	
250 c.c. serosanguineous fluid, 1½ ft. from ligament Treitz a 1¾ in. rent in jejunum involving ¾ circumference, mesenteric hematoma	General	Multiple contusions, laceration of scalp	Died 4 days after operation	Generalized peritonitis
500 c.c. intestinal fluid with partially digested food, 1 ft. from lig. Treitz a rent involving ½ circumference of the jejunum.	Local	Multiple contusions and abrasions	Developed bronchopn. Discharge 22 days P.O.	
300 c.c. of purulent serosanguineous fluid, a ½ in. laceration found 2 ft. from ileocecal valve	General	Shock, fractured pelvis, lacerations of face	Expired on first P.O. day	Generalized peritonitis
300 c.c. bile-stained fluid, 4 in. from ligament Treitz a ¾ in. laceration found in jejunum	Local	None	Discharged 19 19 days P.O.	
50 c.c. of turbid bile fluid, 10 in. from ligament of Treitz ½ in. laceration found in jejunum	Local	None	Discharged 15 days P.O.	
100 c.c. straw-colored fluid with flakes of fibrin, 3 ft. from ileocecal valve a ½ in. laceration found in ileum	Local	None	Developed wound infection, discharged 46 days P.O.	
	General	Shock, fracture of skull with brain laceration	Died 29 days after admission	½ in. laceration in ileum 2 ft. from ileocecal valve, general peritonitis

producing a tear. The other most frequent location for traumatic laceration is within two to three feet proximal to the ileocecal valve. These lesions result when the external force compresses the ileum against the vertebral column or the pelvic bones. Another contributing factor may be the increase in intra-abdominal pressure from external violence. How much the sudden compression of fluid or gas within an intestinal loop contributes to the etiology of this injury is purely speculative.

A study of traumatic perforations of the small intestine at Kings County Hospital is the subject of this communication. From January, 1934, to June, 1943, only eighteen authentic cases, proved by operation or at autopsy, were encountered. Fourteen of these cases will be presented in composite form. The remaining four, which came under our personal care, will be presented in detail.

#### CASE REPORTS

CASE 15.—The patient was a 6 year old colored boy who was brought to the hospital by our ambulance on April 24, 1943. He was found lying in the street after having been struck by a trolley car. There was no history of unconsciousness. An hour following the accident, the patient complained of abdominal pain, was very restless, and vomited twice. The vomitus was gastric contents, no blood in the vomitus recorded.

Examination on admission revealed a fairly well developed, poorly nourished, apathetic Negro boy. His pulse was 104, temperature 101° F, and respirations 22. The significant findings were confined to the abdomen. Diffuse rigidity with marked tenderness was present in the left upper quadrant. Auscultation revealed absent peristalsis.

Blood studies demonstrated a red count of 4,350,000. An hour later the count fell to 3,500,000. The white cells amounted to 11,000 with 89 polymorphonuclears. A preoperative x-ray of the abdomen showed small bowel distention, but failed to indicate a pneumoperitoneum.

A delay in operation occurred due to the refusal of the legal guardian to consent to operation. The child was observed. The record revealed a gradually falling blood pressure associated with a slow rising pulse. Seven hours after the injury the patient was taken to the operating room.

Under general anesthesia, through a midline upper abdominal incision, an exploratory laparotomy was performed. No free fluid was found in the peritoneal cavity. Six inches from the ligament of Treitz a laceration on the antimesenteric border of the jejunum was found. This rent was one inch in length. An inflammatory plastic exudate surrounded this area of perforation. This laceration was repaired in the usual manner, and the abdomen closed in layers. The patient was given a blood transfusion during and following this procedure. The child had an uneventful recovery and was discharged on May 11, 1943.

CASE 16.—This is the case history of a 45 year old white man who was struck by an automobile on the night of June 19, 1943. Following this accident the patient was unconscious. More detailed information could not be obtained.

Physical examination on admission demonstrated the following positive findings. The temperature was 97° F, the pulse 100, respirations 18, and the blood pressure 100/70. A strong alcoholic odor to the breath was present. The patient was unconscious with only slight response to noxious stimuli. Dried blood was present in

both nares and in both external auditory meatuses. Multiple abrasions were noted. The blood mentioned apparently arose from a laceration of the face. Mild to moderate spasm of the abdominal muscles in the upper abdomen was the only abdominal finding of note.

Four hours after admission the patient regained consciousness and complained of abdominal pain. Abdominal rigidity was now generalized with marked tenderness in both lower quadrants. Shortly after this he vomited a moderate amount of dark black material resembling old blood. At this time his blood pressure was 70/40, the pulse was 130, rapid, and thready. Catheterization emptied the bladder of six ounces of clear urine.

The patient was given a blood transfusion, treated for shock, and transferred to the surgical service. Seventeen hours after admission an exploratory operation was performed with a preoperative diagnosis of a perforated abdominal viscus.

A preoperative roentgenogram of the abdomen showed distended loops of small intestine. No evidence of free air under the diaphragm could be demonstrated in this or other roentgenograms.

At operation the peritoneal cavity was found to contain a large amount of slightly cloudy, blood-tinged fluid. Loops of ileum in both lower quadrants were covered with a thin plastic exudate. Two feet proximal to the ileocecal valve, three perforations were found on the antimesenteric border of the ileum. The largest was one inch in length, the smallest one-fourth inch, and the other one-half inch. The usual type of repair was accomplished. Closure of the abdominal incision was in layers with catgut and black silk for the skin.

On the sixth postoperative day the patient developed delirium tremens. He subsequently had a wound infection, but finally left the hospital on the forty-third postoperative day.

**CASE 17.**—This is the history of a 39-year old white peddler who was kicked in the abdomen several times during the course of an attempted robbery. He did not lose consciousness while he was being assaulted. He was taken to another hospital, about 10:00 P.M. on a Saturday night. Here both his chest and abdomen were x-rayed and reported to be negative. At this time a diagnostic paracentesis abdominis in all four quadrants was carried out. This likewise failed to reveal any positive information. After this treatment the patient signed his release from the hospital and went to his home which was in another section of the city. While at home he had moderately severe pain throughout the abdomen associated with constipation. His family physician was called and advised hospitalization. About this time he vomited on two different occasions. There was no blood in the vomitus. He finally entered Kings County Hospital at 3:30 A.M. on Sunday morning (May, 1943). Physical examination revealed the patient as being in moderate distress due to abdominal pain. The temperature was 99° F., the pulse 84, respirations 18, and the blood pressure 100/60. The significant physical findings were confined to the abdomen. Respiratory excursions were limited in the lower half of the abdomen associated with lower abdominal distention. Moderate tenderness was elicited in the right lower quadrant without rebound. Slight rigidity was found in both lower quadrants. There was no obliteration of liver dullness. Peristalsis was not audible. There was no clinical evidence of free fluid in the peritoneal cavity. A reducible right indirect hernia was noted. Rectal examination demonstrated nothing of note.

Flat plate x-ray of the abdomen showed obliteration of the lateral abdominal muscle wall shadow indicating the presence of fluid within the peritoneal cavity. Distention of the small bowel was demonstrated, which was consistent with an adynamic ileus as seen in peritonitis. No free air was visualized under the diaphragm.

The patient was given a blood transfusion and subjected to an exploratory operation four hours after admission. When the peritoneal cavity was entered a moderate amount of cloudy fluid was encountered. Several loops of ileum in the right lower quadrant were adherent to each other by means of a fibrinous plastic exudate. Two perforations in the ileum were discovered, one fourth and one half inch in diameter, respectively. The first was one and one half feet proximal to the ileocecal junction, the other six inches proximal to the first perforation. These perforations were repaired in the usual fashion and the abdomen closed in the routine manner.

The postoperative course was complicated by a grossly infected wound which necessitated secondary closure. The patient was allowed out of bed on the twenty-fifth postoperative day and discharged forty-seven days after operation.



Fig 1.—Free air is clearly visible under the diaphragm indicating a perforation of a hollow viscus (Case 18).

CASE 18.—A 45 year old white man arrived at the hospital at 2 A.M. on June 17, 1943. He complained of pain in the lower abdomen associated with difficulty of urination. All these complaints were of two weeks' duration. In addition he had a productive cough for the same two weeks. The day before admission was the worst day of the entire two week period. The pain became unbearable and the urinary difficulty increased in intensity. Upon questioning by a member of the house staff the patient said that his pain was first generalized, then localized to the right

lower quadrant; vomiting followed the on-set of his first bout of pain. An important bit of information was obtained by the second examiner. The patient informed him that two days before entering the hospital, he struck his abdomen against the side of his bed while attempting to go to the bathroom. As he was getting out of bed, he felt very weak, seemed to faint, fell and struck his right side while falling. Since his fall the abdominal pain has become progressively worse. This pain prompted him to enter the hospital.

Examination on admission showed that the temperature was 103.2° F., respirations 32, pulse 122, and blood pressure 110/60. The significant findings were abdominal. The abdomen was rotund, moved sluggishly with respirations. Right rectus rigidity with right lower quadrant tenderness and rebound were prominent. Peristalsis was markedly diminished on auscultation. A positive Bastedo sign was elicited. Rectal examination demonstrated a fullness in the right pelvis which was tender on compression. The prostate was slightly enlarged. It was thought that the patient had generalized peritonitis due to a perforated peptic ulcer, or due to a gangrenous perforated appendix.

A flat plate of the abdomen and an x-ray of the chest were ordered at that time. The roentgenogram of the abdomen indicated peritonitis. In addition, free air was clearly visible under the diaphragm.

Conservative therapy was instituted. This consisted of intravenous fluids, chemotherapy, blood transfusion, Fowler's position, and sedation as needed.

Four hours later the following note was made. The white blood count had risen from 8,950 with 92 per cent polymorphonuclears to 13,100 with 95 per cent polymorphonuclears. Abdominal signs became more localized to the right iliac region. Obliteration of liver dullness with x-ray evidence of air under the diaphragm indicates a perforation of a hollow viscus. An immediate operation was advised.

An exploratory operation was performed twelve hours after admission. A laceration on the antimesenteric border of the ileum one inch in length was found two feet from the ileocecal valve. Generalized peritonitis was present. The perforated area was adherent to the appendix. It appeared that the appendix was making an ineffectual attempt at walling off the perforation. The appendix itself was surrounded with a dense plastic exudate. Two collections of purulent exudate were found in the pelvis. The perforation was sutured and the abdomen closed after the usual deposition of sulfanilamide into the peritoneal cavity. The prognosis was very unfavorable and the question presented itself as to the advisability of the operation.

Postoperatively the temperature was septic in type rising to 102 and 104° F. The pulse was rapid, thready and of poor quality. On the second postoperative day the patient expired. No autopsy was obtained.

#### DISCUSSION

An analytic study of these eighteen cases brought to light many salient factors of importance. These will be discussed individually. In view of the fact that the number of our cases is limited, it was thought best not to interpret our findings in terms of percentage, but rather to concern ourselves with certain general principles derived from our survey.

The most important single contribution made by the patient, which aids us in arriving at a diagnosis of intestinal perforation, is the history of trauma followed by abdominal pain. Either continuous or intermittent pain which is persistent, associated with vomiting or hematemesis, may indicate visceral injury. Hematemesis is especially prominent in perforations of the duodenum. In our series, five out of seven patients

with rupture of the duodenum or of the jejunum near the ligament of Treitz gave a history of bloody vomitus. The surgeon should not be deceived by a post-traumatic period of freedom from symptoms. A history is possible in which the patient with an intestinal perforation has walked and showed no signs of an abdominal calamity only to seek medical assistance hours following injury.

Examination of the patient in most cases suggests the presence of an acute surgical abdomen. Where a decision cannot be reached as to operability, frequent repeated physical examinations are important. The pulse and blood pressure should be recorded hourly. A steadily rising pulse rate, after the initial shock of injury has subsided, is especially significant. Often a varying picture may be present without any definite physical signs. The patient may eventually enter the hospital for an associated minor injury or because the first noted symptoms were those complicating the injury (most often peritonitis). The evidence of shock may show itself many hours after the injury. This may be due to the leakage of intestinal contents into the peritoneal cavity following an initial walling off of the perforation. Symptoms and signs of peritonitis are present when this state exists.

The diagnosis clinically categorizes these cases into three groups:

1. Those patients with severe multiple injuries which are inevitably fatal
2. Cases that demand immediate surgical intervention
3. Situations in which the diagnosis is doubtful and the indications for and against operation are not definitely established

In the care of this last group the mortality may rise or fall. If there is one sign or symptom pointing to the possibility of a perforated viscus, and the patient is a satisfactory risk, surgery should be undertaken.

An accurate diagnosis may be reached occasionally by means of a flat plate x-ray of the abdomen. These radiographs should be taken in the sitting position or standing when possible. Thus, the free gas in the peritoneal cavity can ascend and is more easily recognized by its concentration beneath the diaphragm. A crescent of sickle-shaped gas accumulation over the liver and beneath the diaphragm can be seen in positive cases. Gas when present is certain evidence of intestinal perforation. If it is absent or unrecognized it does not rule out this possibility. An accurate evaluation of our cases in this regard could not be made since this procedure was omitted in several instances. We have noted, however, that free air under the diaphragm was seen more frequently in perforations of the upper small bowel, especially when the duodenum was involved. This is due to the fact that the stomach contains much air. Thus, when a perforation occurs in its vicinity this air is liberated. Perforations near the ileocecal valve have a tendency to



be walled off by loops of intestine or omentum and infrequently yield sufficient air to be demonstrated under the diaphragm. Moreover, these lower segments do not contain much air. In some cases a paralytic ileus from the injury may be seen by x-ray. This is due to inhibition of peristalsis. The ileus allows a plastic exudate to cover the perforation. Following the ingestion of food, peristalsis commences again. This movement breaks the exudate about the perforation and air may be eliminated and visualized by roentgenogram.

When the diagnosis of small bowel perforation has been made, surgery is contemplated. The preoperative treatment for shock and dehydration is of paramount importance when indicated. Whenever possible, the choice of the anesthetic should be made by the anesthetist. In almost all of our cases general anesthesia was employed.

At operation a right rectus incision was favored. This incision could be extended inferiorly or superiorly as the need arose. Upon opening the peritoneal cavity the type of fluid encountered hinted at the location of the perforation. Perforations in the lower segments of small bowel expel much fluid into the peritoneal cavity. The fluid is typical of small intestinal contents. In lesions of the upper segments little or no fluid is found. Especially is this true if the trauma occurs after the stomach has been emptied. When fluid is encountered it is similar to that seen in perforated peptic ulcers. Duodenal rents may be associated with bile-stained fluid. Retroperitoneal hemorrhage was encountered in one case due to a tearing of the superior pancreaticoduodenal artery.

Identification of the type of fluid in the peritoneal cavity facilitated the exploration of the intestinal tract. When little or no fluid was found, examination of the small intestine commenced at the duodenum and was traced distally. A large amount of fluid indicated that primary exploration should commence at the ileocecal valve and be traced proximally. The perforations in the terminal ileum usually occurred within two to three feet from the ileocecal junction. In this area many cases revealed the perforations to be multiple (two or three). This was contrasted with single lacerations as found in the duodenum or near the ligament of Treitz. In the majority of our cases the lacerations were located on the antimesenteric border and had a tendency to be transverse in direction. When generalized peritonitis was found, the exploratory procedure as described could not be followed satisfactorily.

In some of these cases a prognostic sign was observed beneath the parietal peritoneum. It is known anatomically that the attached surface of the peritoneum is rough, being connected to the inner surface of the parietes by means of areolar tissue termed the subserous areolar tissue. This areolar tissue is covered by a layer of flattened mesothelium which gives the peritoneum its smooth transparent glistening appearance. It has been noted in cases of peritonitis that this mesothelial surface

retains its normal characteristics. However, the subserous areolar tissue alters its appearance. The color becomes a muddy grayish green, due perhaps to extensive and intensive absorption of toxins from the peritoneal cavity. This discoloration is seen where the peritoneum is most closely adherent—as in the middle line of the abdomen. In all cases where this discoloration was observed the outcome was death. This observation has been recorded in cases other than those discussed in this series. At autopsy the discoloration cannot be demonstrated since the peritoneum shows postmortem change and other alterations compatible with peritonitis.

Following the surgical repair of the traumatic perforations, in this series, chemotherapy was employed routinely since the adoption of this therapy for intraperitoneal use. Sulfanilamide, 5 to 10 Gm., and in some instances mixtures of sulfanilamide and sulfathiazole were employed. It is felt that the eventual outcome was not influenced by this therapy.

Of the eighteen cases presented, only eight patients survived. Thus, it can be appreciated how high the mortality is in this type of abdominal trauma. A contributing cause is the multiple injuries. Where severe multiple injuries are present, in addition to the small bowel rents, the outcome is usually death. In the majority of our cases the perforations in the small intestine were the most outstanding injury and with its complicating peritonitis, was the cause of death. In our mortality of ten patients, seven of these had complicating injuries or illnesses. The lowering of this high mortality resides with the surgeon. A decision for or against operation in traumatic abdominal injuries should be made as soon as possible. Ideally, four to six hours after the accident is the most favorable time. Delay, lingering, and waiting are the most common reasons for a fatal outcome. The longer the delay, the more unfavorable is the prognosis. This delay may be due to the patient's failure to seek early medical care. Occasionally the delay is caused by the surgeon who fails to evaluate the serious nature of the injury.

#### SUMMARY

1. Injuries to the small intestine caused by nonpenetrating trauma constitute one of the most lethal conditions encountered in abdominal surgery.

2. Eighteen cases of this type, without evidence of severe injury to the abdominal wall, are presented for critical study.

3. The importance of the history is stressed. This should exclude the possibility of previous abdominal disease, and notation should be made of the time passed since eating or drinking.

4. In the physical findings a progressively rising pulse rate and a change from local to generalized abdominal tenderness with rigidity are indicators for surgical intervention.

5. Roentgenograms of the abdomen are valuable aids in the diagnosis when air is present under the diaphragm. When gas is not visualized

it does not exclude the possibility of perforation of a hollow viscus. Positive x-ray findings are more common in perforations of the upper small bowel than in the lower segments.

6. Leucocytosis may or may not be present.

7. At operation the character of the free fluid in the peritoneal cavity suggests the location of the traumatic pathology.

8. The most frequent sites of rupture are: within two to three feet from the ileocecal junction, the duodenum, and near the ligament of Treitz. Perforations of the ileum often are multiple. Those in the duodenum and the vicinity of the ligament of Treitz are usually solitary.

9. An analysis of these cases demonstrates that an individual of any age may suffer an intestinal perforation. There was a predominance of white male patients in this series.

10. The mortality in visceral trauma is unusually high. Ten of our eighteen patients succumbed to their injuries. The excessive mortality is due in part to multiple injuries. A decrease in mortality rate depends upon improved diagnosis, plus the appropriate time for surgical interference.

#### CONCLUSION

The purpose of this communication was to present the studied results of a surgical problem associated with a high mortality. This problem concerns injuries to the small intestine produced by nonpenetrating forces to the abdomen, however slight they may be. Clinical experience warrants the belief that the unfortunate outcome in many instances, although easily understood, can be prevented, since the surgical repair in almost all cases is not difficult.

Early diagnosis and immediate treatment are the measures necessary for adequate solution to the problem. Perforation of the small intestine is a potential injury following any abdominal trauma. A patient who has sustained an unexpected blow, or other trauma, to the abdomen should be held in suspicion as a candidate for a small bowel rent.

Successful treatment to obtain eventual recovery is dependent upon:

1. Immediate recognition that an intra-abdominal perforation exists.
2. A decision that an operation is necessary provided the patient is a satisfactory operative risk.
3. The least possible delay plus the most rapid method of operative repair. This will tend to decrease what seems to be an unusually high mortality. This mortality is attributed to peritonitis resulting from delayed operation.

It is hoped that this survey has contributed in some way toward facilitating the diagnosis of small bowel perforation. When this diagnosis has been reached, an exploratory laparotomy is imperative. Surgical intervention offers the only hope of recovery in perforations of the small intestine.

## SPINAL ANESTHESIA

### A STUDY OF SAFETY FACTORS AND POSTOPERATIVE PULMONARY COMPLICATION IN 1,344 CONSECUTIVE GENERAL SUR- GICAL PROCEDURES ON NAVAL RECRUITS

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**S**AFETY factors in any anesthetic agent have always been of paramount interest to anesthesiologists and surgeons. This is especially true when anesthesia is induced by the spinal method.

We wish to report our results at the McIntire Dispensary, U. S. Naval Training Station, Great Lakes, Ill., in a group of 1,344 young men admitted to this institution for corrective surgical procedures during a six and one-half month period from Jan. 1 to July 15, 1943. The majority of these recruits were between the ages of 17 and 24 years, the oldest being 39 and the youngest 15. Most of the surgical procedures were of a rehabilitory nature in men entering the service with inguinal hernia, hydrocele, varicocele, or ventral hernia. The remainder of the procedures were for injuries or acute inflammatory diseases the men contracted during their boot training, such as appendicitis, hemorrhoids, and fractures.

This training station draws its recruits from a large area of the United States, extending into the Eastern seaboard, the deep South, and the Pacific Coast. Many of these men have never seen ice or snow and travel here during the winter months in clothing which is quite inadequate. A majority of the recruits arrive at the station after sitting up for twenty-four hours or longer in railway coaches and are suddenly introduced to a vigorous northern climate. Within twenty-four hours they proceed through the recruit examination line. In this period of examination at least two hours are required during which time the men are without clothing. Those requiring surgical attention are withdrawn from this line and transferred for hospitalization. As a consequence of this intimate exposure of men from different localities, respiratory infection is rampant, especially during the winter and spring months.

In February, 1943, we established a surgical preoperative ward in an effort to screen all surgical patients with respiratory infection. All preoperative cases of an elective nature were admitted to this ward which is under the direction of one of the surgical staff. Histories and physical examinations were done on the ward, routine blood studies and a urinalysis obtained, and the temperatures were recorded every four

hours. No man was subjected to a major surgical procedure until he had been observed in the ward for three days, during which time he must have maintained a normal temperature before becoming eligible for surgery. Likewise, no one was operated upon by an elective procedure who demonstrated a very red throat. As an added precaution, the candidates for surgery were inspected carefully the morning they were scheduled for operation. During the six and one-half month period, 173 cases in which the patients were considered satisfactory for operation were canceled on the day they were listed for surgery because of a slight degree of fever, the development of a sore throat, or other symptoms of a mild upper respiratory infection. We are convinced that this careful preoperative study and observation period has paid dividends in lowering our incidence of postoperative respiratory complications.

It is suggested that this report of our results with spinal anesthesia, using different agents, may be of assistance to the surgeon who has not had the good fortune to have available the services of an experienced anesthesiologist. This situation will occur many times during the remainder of the war, especially aboard ship and at small isolated shore stations. When a surgeon, unskilled in the use of anesthetic agents for intraspinal use, is called upon to give a spinal anesthetic, he immediately asks himself several questions:

What agent shall be employed?

What dosage shall be given?

What interspace shall be used?

What shall be the volume of the solution injected?

How shall the operating table be tilted, i.e., head up, flat, or head down?

What if the anesthetic goes too high?

What if the anesthetic is a total failure?

Nowhere can the answer to all these questions be found in any one textbook or any recent article in the literature which is readily available. The Navy has answered one question concerning the agent to be used, since the only preparation on the supply table is procaine hydrochloride. Any other agent must be especially requisitioned.

In this dispensary the surgical procedures were performed by four surgeons. The anesthetics were given or supervised by one of us and an established routine was employed. All patients were given a preoperative hypodermic or morphine sulfate, gr.  $\frac{1}{4}$ , and atropine sulfate, gr.  $\frac{1}{150}$ . This was administered approximately one hour before the scheduled time for operation. Just before the lumbar puncture was done, one-half of a syrette of ephedrine (37 mg.) was given. The remainder was kept sterile for use later in the operation if necessary or for another patient.

The spinal puncture was made in the third or fourth lumbar interspace, with the patient lying on his side, using a 20 gauge needle with a sharp point. Either 150 mg. of procaine or 150 mg. of metycaine were used. The patient was immediately placed on his back following the injection. The table was left flat in all cases, unless the height of anesthesia was inadequate. In this latter case the head of the table was lowered until anesthesia was sufficiently high or the conclusion reached that the anesthetic was unsatisfactory.

This procedure was used in all cases submitting to herniorrhaphy, appendectomy, or operations on the genitals with satisfactory anesthesia persisting for approximately one hour. For hemorrhoids or circumcision, 50 mg. of either metycaine or procaine were employed. For anything above the umbilicus, such as an epigastric hernia or cholecystectomy, and for any procedure where we contemplated more than one hour might be used for the operation, 10 mg. of pontocaine mixed with 100 mg. of procaine were used. This will not be discussed further except to say we have used it fifty-three times in this series with satisfactory results. This combination has been found by one of us (E. D. B.) to be a perfectly safe and reliable anesthetic agent for a single-dose technique, usually giving adequate anesthesia for at least ninety minutes. In general, it is desirable to consider every case submitted to surgery as an individual anesthetic problem, but our experience leads us to believe that this routine as outlined can be safely followed with satisfactory results.

Special anesthetic charts were maintained in a consecutive series of 945 patients operated upon under spinal anesthesia. From Feb. 10 to March 19, 1943, 150 mg. of metycaine were used as the anesthetic agent, being diluted to 4 c.c. with spinal fluid. A series of 259 cases was included in this group. Three inadequate anesthetics resulted, and these were supplemented with local infiltration or pentothal sodium intravenously. Seven patients in this series of 259 developed total sensory anesthesia during the operative procedure. In none of these seven cases could the patients move their arms, nor was pain elicited when traction was made on the hair of their head. Two of them required artificial respiration for about ten minutes. There were no sequelae from this high anesthesia in any instance.

From March 20 to June 1, the anesthetic agent used was 150 mg. of procaine crystals dissolved in 4 c.c. of spinal fluid. There were 337 cases in this series. In none of these cases did the anesthesia extend sufficiently high to produce any respiratory distress. A very few patients experienced slight transient numbness in their fingers but no motor paralysis of the arms was evident. Nine inadequate anesthetics resulted and these were supplemented with local infiltration or intravenous sodium pentothal.

From June 1 to July 1, 1943, metycaine was again employed as the anesthetic agent, using 100 mg. dissolved in 3 c.c. of spinal fluid. In

this series of 164 cases, one unsatisfactory anesthesia was observed, twelve patients developed nausea on the table, and total sensory anesthesia developed on three occasions. This high incidence of total sensory anesthesia confirmed our experience with this agent noted in the previous group of cases.

From July 1 to July 15, 1943, the anesthetic agent employed was again procaine, there being 113 cases in this group. Five of these patients developed nausea and one case of inadequate anesthesia occurred. It is interesting to note that in this latter series, we observed the only case of total sensory anesthesia seen when procaine was the anesthetizing agent. Respiratory paralysis did not develop, the patient responding promptly to inhalations of oxygen. No sequelae developed.

Careful analysis of the blood pressure curves in this series of patients fails to reveal any marked difference in the fall of blood pressure with the two agents used. It seldom occurred that the pressure dropped below 100 mm. of mercury, and in no case was a blood pressure observed that fell below 80. This is to be expected since we were dealing entirely with physically robust young adult men.

In discussing the obvious safety of procaine over that of metycaine, several factors should be taken into consideration. Metycaine in our hands has resulted in fewer anesthetic failures, but we believe its use is more hazardous unless one has at hand means for giving artificial respiration and one skilled in its use. While in any well-organized hospital such means are available, they may not always be present under wartime conditions. Granted, there are more failures of anesthesia with procaine, but in the dosage we have used, and given by the technique outlined here, it is a safer anesthetic for the surgeon to employ for lower abdominal procedures. It is so rare that sensitivity to this dosage of procaine results, that this factor may practically be ignored. In explanation of the higher percentage of failures with procaine, it has been shown since the use of continuous spinal anesthesia by the Lemmon technique that most patients will tolerate large amounts of procaine and that some individuals will require two or three times the dosage we have routinely used in this series before anesthesia develops. One of us (E. D. B.) has observed patients who required 400 mg. of procaine before anesthesia was established and has used as high as 900 mg. in one patient over a period of three hours with no untoward results. One may conclude from this that should a spinal anesthetic with procaine prove to be a total failure, a logical and safe procedure would be to repeat the spinal puncture, giving a second smaller dose of procaine.

There has been less nausea with procaine hydrochloride than with metycaine (Table I). Fifty-one patients out of 519 were nauseated when procaine was the anesthetizing agent, an incidence of 9.8 per cent, while fifty-five cases out of 426 developed nausea on the table when metycaine was used, an incidence of 12.9 per cent.

TABLE I

SPINAL ANESTHESIA; A COMPARATIVE STUDY OF 945 CONSECUTIVE CASES USING TWO DIFFERENT ANESTHETIC AGENTS

AGENT	TOTAL NO. CASES	NO. CASES INADE- QUATE AN- ESTHESIA	NO. PA- TIENTS NAUSE- ATED	NO. CASES HIGH ANES- THESIA	% CASES INADEQUATE	% PATIENTS NAUSEATED
Procaine	519	10	51	1	1.92	9.8
Metycaine	426	4	55	10	.94	12.9

The following measures were employed for reduction of the incidence of postoperative pulmonary complications. All patients were required to breathe a mixture of 10 per cent CO<sub>2</sub> and 90 per cent O<sub>2</sub> for two minutes after completion of their operation and before leaving the operating room. The patient was instructed that he should cough at will if he had any desire to do so. He was shown how to hold his abdomen with both hands when coughing, pressure being exerted not over the incision, but between his umbilicus and costal margins. This is a very important point and gives the patient marked relief from pain when coughing is necessary. After the return of the patient to the ward, the corpsmen were instructed to turn each patient every two hours from side to back and back to side. All patients were given a five-pound paper bag to breathe into while it was firmly held over the mouth and nose. This was done for two or three minutes every two hours the first three postoperative days. Cough mixtures with codeine were not permitted, but expectorant drugs without opiates were employed.

It has been a revelation to us how little morphine was required during the postoperative period to keep these patients comfortable. Morphine was given when necessary for the patient's comfort and no effort was made to limit its use when indicated. The average was less than two hypodermics for each postoperative patient since they simply did not seem to require its more frequent use.

We have stimulated a great interest among corpsmen in postoperative pulmonary atelectasis, and they have been taught to recognize its early signs and symptoms. A sudden postoperative rise in temperature, pulse, and respiratory rate, lagging of the involved chest, and cough, which may be nonproductive, is the usual picture. The early physical findings may be very minimal other than a decreased respiratory excursion and in our experience a mediastinal shift to the involved side is only an accompaniment of a lobar or massive collapse. When a patient does develop atelectasis, the mixture of 10 per cent CO<sub>2</sub> and 90 per cent O<sub>2</sub> is given for at least two minutes every hour, the patient even being awakened for this treatment during the night, until the lung is again re-expanded. In addition, all of these patients are cared for by a special watch who is instructed to turn them from side to side every hour, insist upon deep breathing exercises, and encourage cough-



ing until the obstructing secretion is expectorated. We routinely take bedside x-rays of all such chests, but in many of those with lobular collapse the condition had cleared before the film was taken. The reason for this is that the corpsmen are constantly on the alert for lung complications and begin  $\text{CO}_2$  and  $\text{O}_2$  inhalations as soon as they notify the ward physician that something appears to be wrong with a patient's breathing. We have observed a total of nineteen cases of atelectasis in this series of 1,344 cases, nine being lobar in type and ten lobular in extent (Table II). No case of atelectasis has required bronchoscopic drainage for re-expansion of the lung.

TABLE II

POSTOPERATIVE PULMONARY COMPLICATIONS IN A SERIES OF 1,344 GENERAL SURGICAL PROCEDURES WITH SPINAL ANESTHESIA ON NAVAL RECRUITS

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	TOTAL
Tracheobronchitis	1	1	1	1	0	0	0	7
Atelectasis	2	6	5	0	2	2	2	19
Pneumonia	2	2	0	0	0	0	0	4
Acute catarrhal fever	1	3	2	0	0	0	0	6
Acute tonsillitis	0	2	0	2	1	0	0	5
Total cases pulmonary complications	6	17	8	3	3	2	2	41
Total number major cases	217	211	223	151	141	225	113	1344
Surgical mortality	0	1	0	0	0	0	0	1
Cases canceled A.M. of operation— rise of temperature or acute throat	20	60	34	17	20	12	10	173
Per cent incidence postoperative pulmonary complications	2.4	4.9	2.7	2.0	2.1	.9	1.7	3.1

We have had one death in this series of patients developing atelectasis. However, this individual had a septicemia with metastatic peritonitis and at post mortem the atelectatic area had cleared and was not a factor in the fatal issue.

One of us (C. W. M.) in a previous review of the literature analyzed a series of 22,962 surgical procedures and found the incidence of postoperative pulmonary complications to be 1.38 per cent. In our experience at McIntire Dispensary, 41 patients have developed postoperative pulmonary complications in a series of 1,344 surgical procedures, an incidence of 3.1 per cent. We must admit that this is slightly higher than the average throughout the country but we believe, considering the fact that we are subjecting men who are not native to this locality to surgical procedures, our statistics are what must be expected. We further believe that if these procedures were not carried out, our incidence of postoperative pulmonary complications would have been much higher.

It is of interest to note that all patients in this series received spinal anesthesia. It is a popular but erroneous belief among surgeons that when this anesthetic is used, the danger of postoperative pulmonary complications is lessened.

## SUMMARY AND CONCLUSIONS

1. A series of 1,344 young naval recruits subjected to corrective general surgical procedures under spinal anesthesia are reported.

2. A technique for the administration and control of the spinal anesthetic is outlined and the results with two different anesthetic agents in a consecutive series of 945 cases are presented.

3. A higher percentage of anesthetic failures may be expected when procaine hydrochloride is the agent employed, but this appears to be offset by the greater safety of this drug.

4. Postoperative pulmonary complications were observed in 41 patients in this series of 1,344 cases, an incidence of 3.1 per cent.

5. The routine use of spinal anesthesia does not result in a lowered incidence of postoperative pulmonary complications.

## REFERENCES

1. Eliason, E. L., and McLaughlin, C. W., Jr.: Post-Operative Pulmonary Complications, *Surg., Gynec. & Obst.* 55: 716-727, 1932.
2. Eliason, E. L., and McLaughlin, C. W., Jr.: Post-Operative Pulmonary Atelectasis, *S. Clin. North America* 14: 1-13, 1934.

# SENSITIVITY TO LOCAL APPLICATION OF SULFANILAMIDE\*

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**S**ENSITIVITY to sulfanilamide is not rare, and cutaneous manifestations are well known. However, a widespread cutaneous reaction to the continued local application of sulfanilamide powder over a small wound is certainly worth noting.

## CASE REPORTS†

**CASE 1.**—A 21-year-old Marine was injured in a jeep accident, May 18, 1942. At that time he received two deep abrasions of the left forearm just below the elbow. He was treated by topical applications of sulfapyridine ointment until June 7, 1942, when he came under my care. At this time he had two necrotic ulcers, each about one inch in diameter, occurring about one inch medial to and below the left antecubital space.

Treatment during the next three weeks consisted of daily dusting the wounds with sulfanilamide powder. He showed gradual improvement. The discharge became minimal and the base of the ulcers took on a clean, granulating appearance. The wounds did not decrease in size.

On June 23, 1942, sixteen days after receiving this treatment, he developed what seemed to be a mild sunburn on both shoulders. He was advised to keep out of the sun and sulfanilamide dustings of the wounds were continued.

The next day he reported to the sick bay with a diffuse, bilateral, vesicular rash which was present on both shoulders, arms, forearms, hands, fingers, and palms. The rash was roughly symmetrical on both upper extremities, more marked on the volar surfaces, and most marked in the left antecubital space and around the site of the original wounds. The fingers were swollen and painful, but the rash itself was not painful. Sulfanilamide applications were discontinued and boric acid dressings applied.

On June 27, 1942, three days later, the rash had practically disappeared and epithelial regeneration was noted around the edges of the original wounds, but there was a profuse discharge of pus from the wounds.

On July 2, 1942, sulfanilamide powder was again applied to the wounds, and by the next morning the rash had recurred, identical with its previous appearance. In addition, the patient complained of a dull headache and vague chest pains. Facilities for a laboratory study of the case were not available. By July 5, 1942, two days after the sulfanilamide dustings were again discontinued, the rash had again practically disappeared and the ulcers were epithelizing satisfactorily. On this date the patient was transferred elsewhere feeling quite well.

**CASE 2.**—A Marine received a bullet wound of the calf of the leg during combat in October, 1942. He was treated by daily applications of sulfanilamide powder into the wound, and because of the minor nature of the wound, he was kept on duty. By the middle of November, about one month later, the wound had not improved and had taken on a weepy appearance. The skin surrounding the wound

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\*The opinions or assertions contained therein are the private ones of the writer and are not to be construed as official or reflecting the views of the Navy Department or the Naval Service at large.

†Records of Cases 2 and 3 were destroyed during combat and are reproduced from memory. The record of Case 1 is intact.

was covered with a weepy, vesicular rash. A diagnosis of sulfanilamide sensitivity was made and topical applications discontinued. Within ten days the wound was completely healed.

CASE 3.—A Marine officer received a small shrapnel wound of his back late in October, 1942. Treatment by his unit medical officer consisted of daily topical applications of sulfanilamide powder. This treatment was carried on until early December, 1942. At this time, the wound showed no improvement. He had developed a generalized vesicular rash, similar in appearance to that in Case 1. It was distributed over most of his body surface. Because of this condition he was evacuated to a base hospital out of the combat area.

On his return to his unit in February, 1943, he told me that when he arrived at the base hospital, sulfanilamide therapy was discontinued and he improved rapidly. Then, because he had developed a concurrent dysentery, he was given sulfathiazole by mouth. Within a day or two after being on sulfathiazole therapy, the rash reappeared, but rapidly disappeared when the sulfathiazole was discontinued.

#### COMMENT

There are a number of interesting points brought out by these cases. The first is how much sulfanilamide can be absorbed through a small, discharging wound. It is unfortunate that facilities to determine blood sulfanilamide levels were not available. At least it is apparent that enough was absorbed to sensitize the patient.

From these three cases it would seem that the time required to develop a sensitivity to the sulfanilamide was roughly six weeks. That the patient may be sensitized to other sulfonamides is suggested in the story told by Case 3.

The diagnosis is not always easy in these cases, but once the history of the case is reviewed it becomes apparent. In Case 2, it was suspected before the rash became generalized, and by immediately discontinuing the sulfanilamide powder, a generalized rash was avoided.

In retrospect, it seems that in these cases the sulfanilamide powder inhibited epithelization of the wounds. Throughout these cases the slowness of epithelization was noted, but at the time the slowness of wound healing, so commonly seen in the tropics, was blamed.

It is obvious from a study of these cases that prolonged application of sulfanilamide powder to a wound is not without danger. Under combat conditions with the frequent transfer of patients and the tendencies to spend less time caring for the minor wounds, the dangers of sensitizing a patient to sulfonamides must not be forgotten. As the usual good results obtained from sulfonamides occur within a period of a few days, it seems advisable to discontinue the use of sulfanilamide in a wound after the maximal beneficial effects have been obtained, or if there is no improvement in the first five or six days, to discontinue its use anyway.

#### CONCLUSIONS

1. Three cases of vesicular dermatitis developing following sensitization to the continued application of sulfanilamide powder on small surface wounds have been presented.

2. The sulfanilamide also appeared to inhibit epithelization of the wounds.

3. Withdrawal of the sulfanilamide applications resulted in disappearance of the eruption and epithelization of the wounds.

4. These cases illustrated the potential danger to continued local applications of sulfanilamide.

5. As the beneficial effect of sulfanilamide occurs within a few days, it is suggested that local application of sulfanilamide to a wound be discontinued after five or six days.

## AMINO ACIDS AND BLOOD CLOT RETRACTION

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**D**IMINISHED blood clot retraction usually occurs in patients suffering from thrombocytopenia and frequently in those with hypoprothrombinemia.<sup>1, 2</sup> Any medicament which would increase the degree of clot retraction, even though it did not correct the underlying cause, might be a desirable therapeutic agent. The effects of amino acids on blood clot retraction were recently studied by Rabinowitz,<sup>3</sup> who stated that the addition of 150 mg. of cysteine to 5 c.c. of normal blood, in vitro, would abolish clot retraction for more than twenty-four hours, and that 150 mg. of methionine, cystin, or glycine would neutralize the effect of the cysteine with resulting complete retraction of the clot within three hours. He also reported similar increases in the degree of blood clot retraction after the addition of these amino acids to samples of the blood of five patients suffering from "essential thrombocytopenic purpura." The oral administration of methionine (5 to 8 Gm. daily) to these patients was stated to have restored normal clot retraction and to have controlled spontaneous bleeding.\* Subsequently, Rabinowitz used 5 Gm. of methionine in 1000 c.c. of 5 per cent glucose solution intravenously "in several severe cases of thrombocytopenic purpura with most gratifying results."<sup>4</sup>

We have attempted to repeat and extend these experiments and have been unable to confirm the observations of Rabinowitz.

### METHODS

1. *Blood Clot Retraction.*—The extracorpuseular volume of the clot, a measurement of the fluid occluded within a blood clot, was determined by a method previously described.<sup>4</sup> The extracorpuseular volume of the clot is equal to the difference between the packed cell volume per cent and the volume of the retracted blood clot after incubation of the specimen for one hour at 37° C. The mean value is 9.1 per cent. Values of less than 25 per cent (within two standard deviations of the mean) are considered to be normal.

2. *Platelet Count.*—The method of Rees and Ecker was used and all counts were done by the same technician, who found a normal mean value of 422,000. Values between 248,000 and 596,000, that is, two standard deviations from the mean, are considered normal.

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\*A personal communication from Rabinowitz reveals that cysteine hydrochloride and not cysteine was used in these experiments. The substance to be tested was placed in the bottom of a test tube, the blood specimen was then added, and the blood allowed to coagulate. The tubes were not shaken or inverted.

TABLE I

EFFECT IN VITRO OF CYSTEINE HYDROCHLORIDE, CYSTINE, GLYCINE, AND METHIONINE ON NORMAL HUMAN WHOLE BLOOD, PLASMA, SERUM, AND ERYTHROCYTES

AMOUNT IN MG. ADDED TO 5 C.C. WHOLE BLOOD, PLASMA, OR SERUM				pH OF SERUM	DEGREE OF HEMOLYSIS OF ERYTHRO- CYTES	INHIBITION OF FIBRIN FORMATION IN PLASMA	GEL FORMATION IN SERUM OR PLASMA	EXTRA- CORPUS- CULAR VOLUME OF BLOOD CLOT
CYSTEINE HCL	GLYCINE	CYSTINE	METHIONINE					
5				7.3	++	None	None	10
10				7.0	++	Slight	None	11
15				6.6	++	Slight	None	17
20				6.3	++	Slight	None	22
25				5.9	+++	Marked	None	36
50				1.5	++	Complete	Present	*
75				1.0	++	Complete	Present	*
100				3.4	+++	Complete	Present	*
125				3.0	+++	Complete	Present	*
150				2.6	+++	Complete	Present	*
	150			7.1	0	None	None	10
		150		7.8	0	None	None	18
			150	7.0	0	None	None	7
50	50			1.5	+++	Complete	Present	*
50	150			1.5	+++	Complete	Present	*
50		50		1.5	+++	Complete	Present	*
50		150		1.5	+++	Complete	Present	*
50			50	1.5	+++	Complete	Present	*
50			150	1.5	+++	Complete	Present	*

\*Impossible to measure because of complete absence of fibrin, hemolysis of erythrocytes, and alterations in the plasma.

3. *pH Determinations.*—The pH determinations of the amino acid-serum mixtures were made using a glass electrode-calomel electrode assembly, and the measurements recorded with a vacuum tube electrometer.<sup>5</sup>

4. *Effect of Amino Acids on Serum.*—The various amino acids were added in the desired concentrations to fresh normal human blood serum, thoroughly mixed and placed in a water bath at 37° C. for three hours.

5. *Effect of Amino Acids on Plasma.*—Human blood was drawn into syringes lined with vaselin and quickly transferred to paraffin-lined test tubes and centrifugalized for five minutes at 2,000 revolutions per minute. The supernatant plasma was transferred to test tubes, thoroughly mixed with the desired amount of the amino acids, and placed in a water bath at 37° C. for three hours.

6. *Effect of Amino Acids on Whole Blood.*—The desired quantities of the amino acids were placed in 15 ml. graduated centrifuge tubes to which were added 5 c.c. of freshly drawn human blood. The specimens were thoroughly mixed with a wooden applicator and placed in a water bath at 37° C. for one hour. These were examined and the extra-corpuseular volume of the clot measured.

7. *Effect of Amino Acids on Erythrocyte Hemolysis.*—The desired concentrations of the amino acids were made up in 0.85 per cent sodium

TABLE II

BLOOD CLOT RETRACTION MEASUREMENTS AFTER THE ADDITION IN VITRO OF CYSTIN, GLYCINE, AND METHIONINE TO THE WHOLE BLOOD OF PATIENTS SUFFERING FROM THROMBOCYTOPENIA

CASE NO.	DIAGNOSIS	PLATELET COUNT	MG. OF SUBSTANCE MIXED WITH 5 C.C. SPECIMEN OF BLOOD IN VITRO			EXTRACORPUSCULAR VOLUME OF CLOT
			CYSTIN	GLYCINE	METHIONINE	
1	Chronic idiopathic thrombocytopenic purpura	41,000				51
			50			49
			150			48
				50		55
				150		50
					50	52
2	Chronic idiopathic thrombocytopenic purpura	110,000			150	55
			50			42
			150			38
				50		41
				150		44
					50	51
3	Chronic idiopathic thrombocytopenic purpura	67,000			150	39
			150			40
				150		61
					150	39
4	Polycythemia vera; secondary thrombocytopenic purpura from radioactive phosphorus	91,000				27
			50			31
			150			35
				50		31
				150		36
					50	31
5	Postoperative carcinoma of uterus; secondary thrombocytopenic purpura from roentgen therapy	230,000			150	30
			150			53
				150		46
					150	49
6	Acute idiopathic thrombocytopenic purpura	51,000				53
			50			41
			150			46
				50		45
				150		46
					50	47
					150	40
						43

ehloride. Fresh human red blood corpuseles were added in quantities suffieient to make 2 per cent suspensions. The degree of hemolysis was recorded at the end of two hours at room temperature.

#### RESULTS

The results of the in vitro studies on the blood of normal subjects are summarized in Table I. Cysteine hydroehloride in the conceentrations necessary to inhibit clot retraction strongly acidified the blood, hemolyzed the erythroeytes, coagulated the plasma proteins, and completely inhibited the formation of fibrin. None of these effects were noted with glycine, cystin, or methionine; furthermore they did not counteract any of the effects of cysteine hydrochloride.



TABLE III

BLOOD CLOT RETRACTION MEASUREMENTS AFTER THE ADMINISTRATION OF GLYCINE AND METHIONINE TO PATIENTS SUFFERING FROM THROMBOCYTOPENIC PURPURA

CASE NO.	DATE	DIAGNOSIS	PLATELET COUNT	EXTRACORPUSCULAR CLOT (VOLUME %)	REMARKS
1	9/23/42	Chronic idiopathic thrombocytopenic purpura	41,000	51	Control
	10/ 7/42		33,000	16	After oral glycine, 20 Gm. daily for 11 days
	10/ 7/42		30,000	15	1 hour after 20 Gm. of glycine in milk
	10/ 7/42		32,000	50	2 hours after 20 Gm. of glycine in milk
	10/14/42		36,000	47	After oral glycine, 30 Gm. daily for 7 days
	11/ 9/42		16,000	51	Before methionine
	11/ 9/42		13,000	52	Fifteen minutes after 5 Gm. of methionine in 1000 cc. 0.85% NaCl given I.V.
	11/ 9/42		11,000	53	1 hour later
	11/10/42		13,000	53	18 hours later
2	11/ 6/42	Chronic idiopathic thrombocytopenic purpura	120,000	39	Control
	11/ 6/42		127,000	37	15 minutes after 5 Gm. of methionine in 1000 c.c. 0.85% NaCl given I.V.
	11/ 6/42		121,000	39	1 hour later
	11/ 7/42		120,000	40	24 hours later
	11/16/42		120,000	41	10 days later
	11/21/42		150,000	39	15 days later
6	10/28/42	Acute idiopathic thrombocytopenic purpura in recovery phase	280,000	26	Control
	11/ 4/42		250,000	18	After oral glycine, 30 Gm. daily for 7 days
	11/ 4/42		280,000	25	15 minutes after 5 Gm. methionine in 5% glucose given I.V.
	11/ 4/42		280,000	25	1 hour later
	11/ 5/42		270,000	20	18 hours later
	11/ 9/42		280,000	18	48 hours later
	12/ 2/42		480,000	9	Observations following spontaneous recovery
	12/19/42		350,000	9	

The results of the in vitro studies on the blood of six patients suffering from thrombocytopenia are given in Table II. Blood clot retraction was not significantly altered in any case following the addition of cystin, glycine, or methionine.

The results of the oral administration of glycine and the intravenous administration of methionine are given in Table III. Blood clot

retraction was not improved, nor was the frequency or severity of spontaneous bleeding altered in any of the three patients studied.

### CONCLUSIONS

1. Cysteine hydrochloride inhibits blood clot retraction by acidification of the blood, hemolysis of the erythrocytes, coagulation of the plasma proteins, and complete inhibition of fibrin formation.

2. Cystin, glycine, and methionine do not counteract the effects of cysteine hydrochloride, nor do they increase the degree of blood clot retraction when added in vitro to the blood of patients suffering from thromboeytopenia.

3. The administration of glycine or methionine to patients suffering from thromboeytopenia does not increase the degree of blood clot retraction nor aid in the control of abnormal bleeding.

### REFERENCES

1. Aggeler, P. M., Lucia, S. P., and Hamlin, L. H.: Blood Clot Retraction: I. Measurement of the Extracorporeal Volume of the Clot, *J. Lab. & Clin. Med.* 28: 89-97, 1942.
2. Lucia, S. P., Aggeler, P. M., and Hamlin, L. H.: Blood Clot Retraction: II. The Significance of the Extracorporeal Volume of the Clot and Its Clinical Application, *Am. J. M. Sc.* 204: 507-516, 1942.
3. Rabinowitz, H. M.: A Study of the Role of Amino Acids in Clot Retraction. The Effect of Methionine in Restoring Normal Clot Retraction and Control of Bleeding in Essential Thromboeytopenic Purpura, *Am. J. Surg.* 51: 366-378, 1941.
4. Rabinowitz, H. M.: Personal communication.
5. Goyan, F. M., Barnes C. L., and Hind, H. W.: Universal pH Meter and Simplified Vacuum Tube Electrometer, *Indust. & Engin. Chem.* 12: 482, 1940.

# Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M.D.

## PROGRESS IN SURGERY OF THE AUTONOMIC NERVOUS SYSTEM, 1940-1942\*

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THE war has nearly dried up the flow of articles in the Continental journals which deal with laboratory and clinical observations on the autonomic nervous system. Nevertheless, much work of interest continues to emanate from Great Britain, and the number of papers of value published in this country has barely begun to fall off. In spite of the difficulty of reviewing such a complicated subject while on active service with the Navy, I feel this task should be undertaken before an overwhelming mass of material has accumulated. In the present review an attempt is made, therefore, to summarize the more important laboratory and clinical findings that have been published during the three years since the previous report.<sup>1</sup> The reader who is particularly concerned with the anatomic and physiologic aspects of this branch of neurology should consult the excellent reviews by Hare and Hinsey,<sup>2</sup> whereas the monograph of White and Smithwick,<sup>3</sup> published in 1941, is available for the clinical investigator and the physician who wish to review the fundamental aspects of the field and their clinical application in a single volume. In no field has the surgeon been more indebted to recent contributions of the anatomist and the physiologist.

### ANATOMY AND PHYSIOLOGY

As in the somatic system, autonomic reflexes are integrated by the central nervous system according to the principle of functional levels. This interesting analogy was pointed out by Fulton,<sup>4</sup> who developed the simile further by pointing out that only simple vasomotor, visceral, and sexual reactions are integrated at the spinal level, whereas at the level of the medullary stratum are organized the reflexes essential for the maintenance of a constant blood pressure. Other combined reactions such as salivation and vomiting, also developed at this level, repre-

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sent combined reactions of the autonomic and somatic systems. The hypothalamic level is far more complex. Here take place temperature regulation, determination of estrus, control of carbohydrate, fat, and water metabolism (see articles which were presented in the symposium on the hypothalamus before the Association for Research in Nervous and Mental Disease<sup>5</sup>). Fulton further summarized the evidence for a rich and varied representation of autonomic activities in the cerebral cortex. Disturbances of visceral activity, metabolism, etc., which have been produced by lesions of the frontal areas, indicate that in man the hypothalamic level is under the direct control of the cortex.

Another proof of cortical dominance over the hypothalamus is the intensive autonomic discharge which is released when these higher centers are removed by decortication. The term "sham rage" was originally suggested by Cannon and Britton<sup>6</sup> to describe the spontaneous outbursts of motor activity in cats which occur when the cortex is disconnected from the lower hypothalamic centers and resemble responses to rage and fear. Wortis and Maurer<sup>7</sup> have recently described this phenomenon in two human cases after destruction of the higher centers by insulin hypoglycemia and by carbon monoxide poisoning. In both cases the emotional outbursts were in no wise purposeful and therefore appeared to be an uninhibited discharge of the autonomic centers in the hypothalamus. Sjöqvist<sup>8</sup> suggests that hypothalamic discharge may occur under pathologic conditions, in connection with ordinary epileptic seizures, and also in acute obstructions of the cerebrospinal fluid pathways. The syndrome originally referred to by Penfield<sup>9</sup> as diencephalic autonomic epilepsy Sjöqvist believes is due to acute distension of the third ventricle with stimulation of the autonomic nuclei which lie within its walls. There has arisen a tendency even among psychiatrists to stress unduly the role of the hypothalamus in the emotional aspects of behavior. Masserman,<sup>10</sup> however, rightly points out that in the present state of knowledge it would seem safest to assign to the hypothalamus its experimentally demonstrable role in re-enforcing and coordinating the neural and hormonal mechanisms of emotional expression, and reserve for more adequate proof the hypothesis that it is either the dynamic source or the seat of experience of affective states. "An emotion is a highly complex conative and cognitive as well as affective state in which not only the central nervous system but the entire organism functions as a psychobiologic whole."

A verification in man of earlier experimental evidence pointing to the hypothalamic control of the waking-sleep rhythm is a finding of much clinical interest recently stressed by Globus.<sup>11</sup> In an analysis of two patients studied clinically and anatomically it was observed that protracted somnolence was a striking symptom, and at post-mortem circumscribed lesions were discovered in the diencephalic-mesencephalic region. These lesions were situated bilaterally and corresponded closely

in location to the experimental lesions produced by Harrison<sup>5</sup> in cats. There is still greater accord with the area outlined by von Economo as the center for regulation of sleep. Globus concludes that, although the importance of the more caudal parts is still subject to discussion, it seems probable that the periventricular hypothalamic gray matter is the area containing cell aggregations which functions as a sleep-regulating center.

The position of the descending pathway of the sympathetic fibers in the medulla, located experimentally in animals by Magoun,<sup>5</sup> has been confirmed in man by an observation of Duthie and Mackay.<sup>12</sup> In measuring skin temperatures of the extremities in a patient after thrombosis of the left posterior inferior cerebellar artery, they found that the cutaneous vessels of the left hand remained fully dilated six months after the lesion occurred. The posterior inferior cerebellar artery supplies the medulla oblongata in the region dorsal to the inferior olive and lateral to the hypoglossal nucleus. In addition they noted miosis and absence of sweating of the left arm and face. The sympathetic fibers running from the hypothalamus to the lateral horn cells traverse this area and constitute the highest neurone of the sympathetic nervous system. They do not cross below this level, and the fact that vasodilatation is complete shows that there can be little if any autonomous activity in the lower spinal centers or in the chain of peripheral sympathetic ganglia.

An exact knowledge of the segmental outflow of the vasoconstrictor and sudomotor fibers from the spinal cord is of the greatest importance for successful operative treatment of Raynaud's disease and hyperhidrosis. This had been based on experiments in lower animals performed by Langley, in 1891.<sup>13</sup> With modern electrical methods of recording nerve impulses, Sheehan,<sup>14</sup> Sheehan and Marrazzi,<sup>15</sup> and Geohagan and associates<sup>16</sup> have investigated the segmental outflow in the monkey and man by stimulating the anterior spinal roots. In man it is now established that the highest vasoconstrictor fibers to the upper extremity emerge in the second thoracic nerve and are present in each succeeding anterior root down to the ninth or tenth thoracic level. Exception has been taken to these findings by Kuntz and Dillon,<sup>17</sup> who claim to have demonstrated the presence of preganglionic sympathetic components in the first thoracic nerve in cats and monkeys. Kirgis and Kuntz<sup>18</sup> have stated that in certain cases there may even be a communicating ramus from the eighth cervical nerve which carries preganglionic fibers to the brachial plexus via the middle cervical ganglion. It is difficult to accept the validity of these observations, which are at variance with findings in many patients where the upper extremity has been totally sympathectomized, although the first thoracic ramus communicans has been left intact.

## SYMPATHECTOMY IN PERIPHERAL VASCULAR DISEASE

Outstanding descriptions of peripheral vascular disease have been written by Seupham, de Takáts, Van Dellen, and Jesser<sup>19\*</sup> and by Homans.<sup>20</sup> In the typical advanced case of Raynaud's disease, all observers are now in agreement with Lewis<sup>21</sup> that the phenomenon of intermittent color changes in the digits is due to abnormal contraction of the arterioles in direct response to cold. In these advanced cases, where blanching is caused by ischemia of the fingers, the digital arterioles are the seat of occlusive changes.<sup>3</sup> But before this stage is reached these patients usually have suffered from cold and more or less cyanotic extremities for a number of years, and the condition in the feet is not likely to advance beyond this point. As a rule the extremities are abnormally moist and the sweat glands, which are activated by the sympathetic nervous system, respond excessively to emotional stimuli. In the cases where Raynaud's crises of pallid asphyxia are not present, all gradations are seen between a pink, moist, warm hand and a cyanotic wet one. The latter condition is commonly classified as acrocyanosis and resembles Raynaud's disease, except that there are no episodes of blanching. Furthermore, the trophic changes, ulceration, and gangrene, which appear in the most severe cases with complicating scleroderma, have not been reported in true acrocyanosis. The causative factor in this condition, as well as in true Raynaud's disease, has been attributed by Lewis<sup>21</sup> to a local fault in the blood vessels, and he also believes that constrictor impulses play little part in its production. Barker and Baker<sup>22</sup> have described in detail a typical case of acrocyanosis in which the incapacitating symptoms and color changes disappeared after sympathectomy. They feel, as do White and Smithwick,<sup>3</sup> that vasomotor impulses are the primary initiating factor in the production of arteriolar spasm. The closely related syndrome of hyperhidrosis, in which the hands are excessively sweaty as well as frequently cold and cyanotic, is equally amenable to sympathectomy. In this condition there can be no question as to the etiologic role of the sympathetic nervous system. The sweat glands are activated by sympathetic impulses and are in no way susceptible to the direct effects of cold.

A confusing factor in evaluating the role of the sympathetic vasoconstrictor fibers in Raynaud's disease has been the all too frequent poor relaxation of the blood vessels in the upper extremities following attempts at sympathetic denervation. The fact that vasoconstriction is nearly always abolished in the lower extremities after resection of the lumbar ganglia has been conveniently overlooked by writers such as Hyndman and Wolkin.<sup>23</sup> Johnson,<sup>24</sup> after studying twenty-two patients with Raynaud's phenomena, has even reached the conclusion that sympathectomy has been a complete failure and that circulation (tested

\*This extensive review has been written in two parts; the first, which summarizes recent literature, is written by Van Dellen and Seupham; the second, on surgical treatment, by de Takáts and Jesser.

by the finger phethysmograph) returns to the preoperative level in a short time. He presents five case reports in support of this statement. A critical examination of his account reveals that two patients were operated on when indications for surgery were doubtful (cases of rheumataid arthritis and of syphilitic endarteritis); the conclusions are based on operative results in the upper extremity, and in several of his cases the operations were manifestly incomplete.\* Furthermore, his observations were not carried out under constant basal conditions, and the surface temperature of the fingers before operation was so high that normal vasoconstrictor tone must have been nearly abolished. These faulty observations have been criticized in detail by de Takáts and associates<sup>19</sup> and by Smithwick.<sup>27</sup> Johnson's plethysmographic pulse volume curves, which show a rapid return to the preoperative deficient level of blood flow, are in striking contrast with those obtained after anatomically complete and physiologically effective types of denervation, provided these determinations are made under conditions where vasoconstrictor tone would normally be present.

Out of the extensive clinical and experimental evidence collected in the past decade has emerged the fact that certain fundamental principles must be observed by the surgeon in order to get the best clinical results (Smithwick<sup>27</sup> and White and Smithwick<sup>3</sup>). First, it seems clear that the operation must thoroughly interrupt the sympathetic vasoconstrictor fibers. If even a few remain intact, secretion of sympathin at their endings is capable of exciting contraction in all the denervated smooth muscle cells in the vascular walls. In the second place, the best results have been obtained by the interruption, as far as possible, of preganglionic fibers only. This fundamental physiologic principle has been corroborated by Learmonth,<sup>26</sup> de Takáts and associates,<sup>19</sup> Atlas,<sup>27</sup> and numerous other students of peripheral vascular disease. In the third place, time has demonstrated conclusively the tremendous regenerative power of interrupted sympathetic fibers, especially after the preganglionic axone has been divided. These principles are adequately fulfilled when the second and third lumbar ganglia are resected, as they carry only preganglionic components to the sciatic nerve and their removal produces a gap of sufficient length to prevent regeneration. It is important to remember that bilateral removal of the first and second lumbar ganglia is likely to result in sterility in the male through paralysis of the ejaculatory mechanism, but the resection must include the first lumbar ganglion in order to produce a maximal increase in circulation through the upper leg. Its removal is therefore necessary in cases of thromboangiitis obliterans and in high arterial ligations, but it should be spared in the ordinary case of vasospasm, where increasing the circulation below the ankle is all that matters. The various types

\*The assumption that the denervation must have been incomplete is based on the fact that either sweating or vasodilatation after nerve block were demonstrated soon afterward, and in one case the vasomotor paralysis was so brief that it did not outlast the traumatic effects of the operation.

of surgical approach and management of the important ganglia necessary to sympathectomize the arm and leg have been described by Ochsner and DeBailey.<sup>28</sup> The best description of the problems involved in preganglionic sympathectomy of the arm and the prevention of regeneration has been given by Smithwick.<sup>29</sup> He advocates division of the chain below the third thoracic ganglion and intradural division of the second and third thoracic anterior spinal roots so that their subsequent outgrowth will be checked by an intact dura. In order to prevent reconnection of the two divided ends of the chain, Smithwick has been covering the mobilized upper portion of the trunk with a cylinder of fine silk and transplanting its free lower end into the muscles of the back. While the results of this operation have been distinctly superior to those of the older method of cervicothoracic ganglionectomy, occasional recurrences of vasoconstrictor tone are seen after a period of months, due to regeneration. The suggestions of Atlas<sup>30</sup> and of Hyndman and Wolkin<sup>31</sup> that an effective sympathectomy of the arm can be carried out by removing only the second thoracic ganglion are open to the criticism that the fibers interrupted over such a short extent are nearly certain to regenerate.\*

It should be frankly admitted that the problem of regeneration of the preganglionic fibers after upper extremity sympathectomy has not been entirely solved. Geohegan and Aidar<sup>32</sup> have made the intriguing suggestion that recovery of sympathetic tone may not necessarily be due to regeneration, but to reorganization of function within the sympathetic system itself; that the first thoracic root, which ordinarily carries no vasoconstrictor fibers to the upper extremity, may develop such a function. They cite a case in which the patient was operated upon by Ray.<sup>33</sup> The ventral roots from the second through the ninth thoracic root were sectioned (all the roots which gave a decrease in electrical skin resistance on direct stimulation), with subsequent evidence of complete sympathetic denervation of the hand. Within ten weeks, however, evidence of returning function was clear-cut. The shortness of this interval suggested that it might have come about in some other way than through regeneration of axones. An analogous situation was created in cats, and it was found that after interruption of preganglionic pathways to the forepaw, new pathways developed from higher spinal roots, which normally contribute no outflow to the upper extremity. The implication of this theory is that, although the first thoracic root normally gives off no demonstrable vasoconstrictor impulses to the upper extremity, it may develop such a function after the usual pathways have been interrupted. This concept may fit in with Kuntz and Dillon's<sup>17</sup> findings quoted in the section on anatomy. While surgeons are in agreement that recovery of vasoconstrictor tonus is still a problem after preganglionic sympathectomy, many are not aware

\*Three patients in whom White removed both the second and third thoracic ganglia showed clear-cut regeneration within a period of six to nine months.



of the fact that recurrence may also take place after cervicothoracic ganglionectomy, an operation which destroys most of the postganglionic cells sending fibers to the brachial plexus. This has been described by Sheehan<sup>34</sup> and also by White and Smithwick.<sup>3</sup>

It has been suggested by Fatherree, Adson, and Allen<sup>35</sup> that "adrenaline sensitization" does not satisfactorily explain the poor results of cervicothoracic ganglionectomy in Raynaud's disease and that there is no particular advantage in performing the preganglionic type of sympathetic denervation. This contradicts firmly established physiologic principles and is at marked variance with clinical findings in a large series of patients investigated by the peripheral vascular clinic at the Massachusetts General Hospital. White and Smithwick<sup>1</sup> have recorded how cervicothoracic ganglionectomy (postganglionic denervation) had to be given up in 1935 because vasoconstrictor activity recurred so frequently within a period of two weeks following operation through the direct action of circulating sympathomimetic hormones. In monkeys, after cutting the anterior spinal roots from the second to the tenth thoracic roots, which carry the preganglionic vasoconstrictor fibers to the upper extremity, White (see discussion of paper by Smithwick<sup>29</sup>) found that the hand remained vasodilated. But if subsequently the inferior cervical and the first and second thoracic ganglia, which contain the cells of the postganglionic vasoconstrictor fibers, were resected, the hand cooled to nearly room temperature whenever the monkey became excited or small amounts of adrenaline were injected. The same unfavorable response was demonstrated by Ascroft,<sup>36</sup> in the lower extremity of a monkey by destroying the postganglionic cells after a successful preganglionic sympathectomy. Atlas<sup>37</sup> has recently confirmed this phenomenon in a human subject by performing a preganglionic sympathectomy in a man with paralysis of the median nerve, who suffered from aching pain, coldness, and cyanosis in the area to which the postganglionic fibers had been destroyed. Ten months afterward, the intravenous injection of adrenaline caused a drop in surface temperature of 4.1° (F.) of the fingers which had been sensitized by postganglionic denervation, and a fall of only 1.2° in the little finger.

In occlusive vascular disease of the extremities an abnormal degree of vasospasm may be an added factor that leads to gangrene. Surgical intervention upon the sympathetic nervous system is very helpful in the management of some of these patients.<sup>3, 25</sup> While arteriosclerosis in diabetics is almost never associated with a significant degree of vasospasm, thromboangiitis obliterans frequently has a large element of arterial spasm. This is also occasionally the case in uncomplicated arteriosclerosis. In dealing with these patients it is preferable to demonstrate by one method or another that the circulation can be improved before recommending sympathectomy. There is, however, a small group in which preliminary tests do not indicate a striking release of vaso-

spasm and yet experience has shown that sympathectomy may still be surprisingly worth while. At present these can only be selected on the basis of a wide clinical experience.

Sympathectomy has been employed by the peripheral vascular clinic at the Massachusetts General Hospital with increasing frequency in cases of thromboangiitis obliterans, generally in combination with other forms of treatment such as minor amputation of digits and crushing of peripheral nerves. Statistics of patients with the disease sufficiently advanced to require hospitalization<sup>3</sup> show that when only nonsurgical preliminary treatment was used (rest, vascular exercises, cessation of smoking) the proportion of major amputations amounted to 74 per cent. After the value of crushing peripheral nerves was recognized in 1930, the need for major amputations dropped to 30 per cent. Without adding any therapeutic method of importance except the release of vasospasm by sympathectomy, the incidence of major amputations has fallen to 15 per cent in the last ten years. While lumbar sympathectomy has been found to reduce the need for leg amputation when the popliteal artery is obliterated from 47 to 13 per cent, it is usually of no avail when all main vessel pulsations including that in the femoral artery are lost, especially when ulceration, infection, and gangrene are already present.

New applications of sympathectomy in other forms of peripheral vascular disease have been proposed during the last three years. In thrombophlebitis the role of reflex vasospasm and the therapeutic value of its release by procaine infiltration of the regional sympathetic ganglia, originally proposed by Leriche and Kunlin,<sup>37</sup> has been effectively demonstrated by Ochsner and DeBakey.<sup>38</sup> They point out that the concept of mechanical blockage of the venous and lymphatic trunks fails to explain the entire clinical picture; that many of the symptoms and signs are due to spasm of the arterial and venous systems; and that the vasoconstricting stimuli originate in the thrombophlebitic segment. As a result, filtration pressure is raised, capillary permeability is increased by anoxia, and flow of lymph is diminished. Re-establishment of a more normal exchange of intravascular and perivascular fluids can be produced by paravertebral infiltration of the sympathetic ganglia with procaine hydrochloride. Whereas in phlegmasia alba dolens there is often pyrexia for four to six weeks, a sense of painful distension of the tissues, and the likelihood of persistent edema, varicosities, and ulceration, there was a striking contrast in the cases treated by injection. Pain was relieved promptly in all instances. There was a more rapid return to normal temperature and disappearance of edema. Sixty per cent of the patients were discharged from the hospital as cured within eight days of the first therapeutic procaine block.

Erythromelalgia, a rare condition in which the lower extremities become red, hot, and painful, is not usually amenable to medical treatment and may be a cause of prolonged incapacity and discomfort. Tel-

ford and Simmons<sup>39</sup> have reported two patients who have been relieved of all their symptoms and signs by resection of the lumbar sympathetic chains.

Intermittent claudication, another condition which may incapacitate older individuals, is caused by the pain which develops in working muscles in the absence of an adequate circulation. Opinion has been divided concerning the efficiency of lumbar sympathectomy for relieving the pain and increasing the walking distance. Freeman and Montgomery<sup>10</sup> have measured the severity of intermittent claudication in twelve patients with obliterative vascular disease, both before and after blocking the sympathetic ganglia with procaine. Of this number, six who obtained relief from paravertebral injection were subsequently subjected to lumbar sympathectomy. Particular efforts were made to include the first lumbar ganglia, as this is essential to ensure vasodilatation of the arterial tree above the knee. Immediate and persistent relief was obtained in five out of the six cases. Similar favorable results have been recorded by White and Smithwick,<sup>3</sup> only these observers found that an unsatisfactory response to diagnostic procaine block does not necessarily preclude a satisfactory result after permanent denervation. One may conclude that, although it is true that intermittent claudication is caused by arterial occlusion, which is usually organic in nature, in many cases there may be a superimposed element of abnormal constriction which aggravates the circulatory deficiency, and that a high lumbar sympathectomy can often benefit these cases. One is tempted to ask why such improvement should occur, when the physiologists report that an increase in circulation through muscle is brought about by sympathetic stimulation or the secretion of adrenaline. Freeman and Montgomery believe that this apparent contradiction is explained by the fact that, although sympathetic stimulation dilates the muscle capillaries, at the same time it constricts the arterioles and larger arteries of the leg to such an extent as to interfere with the delivery of blood to those capillaries.

The reports of surgeons who have been forced to ligate the major arteries of the extremities at points where subsequent gangrene is a serious risk have brought out with increasing emphasis the protective value of preliminary or concomitant sympathectomy or other methods of abolishing vasoconstrictor tone in the early period before a collateral circulation is established. Learmonth<sup>41</sup> has summarized the value of removing vasoconstrictor tone over this critical period. This may be accomplished temporarily by two methods: by heating a sufficient area of the body, excluding the threatened area (which should be kept cool), to ensure reflex vasodilatation; or by injecting procaine solution followed by 95 per cent alcohol about the sympathetic fibers destined for the threatened limb. He adds that when either the femoral or the popliteal artery must be permanently occluded, if the patient's condi-

tion permits, it is wise to combine any operative procedure on the vessel with a sympathectomy. This not only provides the maximum collateral circulation at the critical period, but also is a good investment for the future nutrition of the limb. Arguing along these lines, Veal<sup>42</sup> has pointed out that, whereas the postoperative circulation may be adequate when the patient is at rest in a warm environment, it may yet be wholly inadequate under the stress and strain of normal function. The surprising effectiveness of this procedure is brought out in an article by Richards and Learmonth,<sup>43</sup> who quote skin temperature readings in a case of popliteal aneurysm before and after a preliminary lumbar ganglionectomy and after radical excision of the aneurysmal sac. For ten hours after resection of a portion of the popliteal artery and three of its five collateral branches, skin temperature records were taken from the great toes. After remaining at or near the level of the environment for five hours, the temperature of the great toe on the side of the operation rose gradually. Twenty-four hours after operation, in a room at 70° F., its temperature had reached 92° F., and ten days later it was 7° warmer than the control area on the opposite side. These records show the adequacy of the collateral circulation resulting from a preliminary "elimination of the sympathetic vasoconstrictor tone. Similar dramatic results have been reported by Atlas<sup>44</sup> in a case of excision of a traumatic aneurysm which extended from just below the origin of the internal iliac artery to a point just short of the origin of the deep femoral. For thirty-five years following the ligation of the superficial femoral artery this patient had suffered from severe ischemia of the foot and leg with chronic ulceration, and the aneurysm had reached an alarming size. Six months after its excision, which included the total length of the external iliac and femoral arteries, the foot was pink and warm, the leg ulcers had remained healed, and there were no symptoms of ischemia other than a mild degree of intermittent claudication. From the surgical clinic of Tulane University, Gage<sup>45</sup> reports that in fifteen cases of arterial and arteriovenous aneurysms, collateral circulation has been rapidly developed and maintained by either injection or ablation of the regional sympathetic ganglia. He advocates alcoholic injection of the lumbar ganglia and either repeated injection of the upper thoracic ganglia with procaine or their resection, as injection of alcohol in this region is likely to be followed by neuritis. After a preliminary excision of the upper lumbar sympathetic ganglia, Leriche<sup>46</sup> has been able to resect the terminal portion of the aorta and common iliac arteries in two patients without jeopardizing the circulation to the lower extremities.

#### SUDOMOTOR MECHANISMS

The occurrence of excessive and incapacitating sweating in the palms of the hands and soles of the feet is due to abnormal activity on the part of the autonomic nervous system and has been consistently relieved

by sympathectomy. Two interesting cases of hyperhidrosis localized in a single hand and caused by irritation of the brachial plexus by a cervical rib have been reported by Telford.<sup>17</sup> The phenomenon disappeared after removal of the accessory rib. Gurney and Bunnell<sup>18</sup> have made a study of the sweat glands after denervation and found that no visible histologic change results. This explains why these glands are able to start functioning again months after nerve injury if the sympathetic fibers regenerate. Even when totally denervated, the glands are able to respond to intraaneuric injections of mecholyl or to excessive local stimulation by heat. Hyndman and Wolkin<sup>19</sup> state that sweating may occur on two surfaces of sympathectomized skin which are in contact, such as the axilla or antecubital fossa when the forearm is flexed. In a study of the anterior spinal roots over which sudomotor impulses emerge, these writers find that the second thoracic root carries the greatest number of fibers to the head and upper extremities. Section of the upper five anterior thoracic roots bilaterally causes almost complete anhidrosis of the face and hyphidrosis down to the second dorsal segment, whereas section from the third to the ninth inclusive does not noticeably diminish sweating. As is true of preganglionic sympathetic axones in general, the sweat fibers in any anterior root are distributed to at least four or five sympathetic ganglia. In the spinal cord, complete section of the anterior and anterolateral column does not diminish sweating unless the result is complicated by injury to the pyramidal tracts. Hyndman and Wolkin conclude that the autonomic tracts which subserve sweating are probably situated just anterior and close to the pyramidal tracts. While complete transverse myelitis at the eighth cervical segment abolishes thermoregulatory sweating, the sweat glands regain their activity if the descending tracts recover. When sweating is lost over a large portion of the body, the activity of the remaining normal glands shows a great compensatory increase.

In a second article on sweating, Hyndman and Wolkin<sup>20</sup> point out that pilocarpine in  $\frac{1}{6}$  gr. doses is a valid method of differentiating between paralysis of pre- and postganglionic fibers. Provided that sufficient time for fiber degeneration has elapsed following a postganglionic denervation, the areas of anhidrosis after a hypodermic injection of the drug will agree precisely with the loss of thermoregulatory sweating, whereas after a preganglionic denervation pilocarpine will induce copious secretion of sweat by its peripheral action. Perhaps the simplest method of outlining areas of skin which have been sympathectomized is by the alteration of electrical resistance. While the increase in cutaneous resistance that follows sympathetic denervation has been known for some time, Riechter and Woodruff<sup>21</sup> have simplified and popularized the method of mapping out areas of high skin resistance by the passage of a very small direct current. The sharp demarcation between the denervated areas and the surrounding skin of normally low resistance is a most convenient test. Wherever the sweat glands are para-

lyzed, skin resistance is increased. In this way it is possible to map out the affected areas of body surface after injuries to the spinal cord, peripheral nerves, or sympathetic pathways.

#### IRRITABLE CAROTID SINUS

Most persons who have an abnormally active carotid sinus suffer only mild symptoms which can be relieved by simple nonoperative procedures, such as the avoidance of a tight collar and of sudden turning of the head, or administration of atropine and mild sedation. But there are a few individuals with such an irritable reflex that they suffer from attacks of asystole and hypotension which lead to syncope, or they may develop severe convulsive seizures with loss of consciousness. Diagnostic compression of the region of the carotid bifurcation should be tested in all individuals who suffer from unexplained heart block, syncopal attacks, or unusual epileptic seizures, especially if they are of arteriosclerotic age. This reflex syndrome responds remarkably to denervation of the carotid sinus. To the long list of successful results published in recent years, a number of interesting cases have been added by Mulholland and Rovenstine<sup>52</sup> and by Ray and Stewart.<sup>53</sup> An unusual case of atypical epilepsy has been reported by Romano, Stead, and Taylor,<sup>54</sup> in which preoperative electroencephalographic studies made during pressure over the carotid bifurcation showed changes compatible with psychomotor and grand mal seizures. In this and in another similar case reported by White and Smithwick<sup>3</sup> the abnormal brain waves as well as the seizures were relieved, temporarily by diagnostic procaine block, and permanently by surgical denervation. In Ray and Stewart's article it is also brought out that a hypersensitive carotid sinus reflex may be associated with tuberculous cervical nodes. The serious complications that may result from operative manipulations of the sinus region should be borne in mind by every surgeon and anesthetist. These have been emphasized by Leger,<sup>55</sup> Weese,<sup>56</sup> and Ruzicka and Eversole.<sup>57</sup> Serious cardiovascular collapse may occur during drainage of cervical abscesses or during manipulation of the superior pole of the thyroid gland, especially if the sinus reflex has been sensitized by digitalis, or when gas, light chloroform, or barbiturate anesthesia is used. Even ether cannot be counted upon to abolish a hypersensitive sinus reflex, in which case recourse must be had to infiltration of procaine between the external and internal carotids. It would seem wise to submit every patient who is to undergo a cervical exploration to a preliminary test by compression of the sinus area.

#### SYMPATHECTOMY IN THE TREATMENT OF ESSENTIAL HYPERTENSION

In the three years since the preceding review the value of surgical intervention in the treatment of essential hypertension has been firmly established, and more effective methods of releasing vasoconstrictor tone in the lower half of the body have been worked out. In general,

as aptly summarized by Grimson<sup>78</sup> in his discussion of the surgical treatment of hypertension, the lowering of the blood pressure observed has been directly proportional to the extent of the sympathectomy and inversely proportional to the severity of the disease. The constriction of cutaneous blood vessels by the sympathetic vasomotor nerves has been recognized for many years, but current teaching has indicated that the far more extensive vascular tree to the muscles is dilated by sympathetic impulses and also by adrenaline. This is undoubtedly true of the terminal vessels, but the recent re-examination of vasomotor control in the muscles of the forearm and calf by Wilkins and Eichna<sup>59, 60, 61</sup> has disclosed that reflex vasodilatation on warming and reflex vasoconstriction on cooling of the body are mediated by the sympathetic nervous system, as is the case with the cutaneous vessels to a far greater extent. These reflex changes are abolished by preganglionic sympathectomy and blood flow is stabilized at a point somewhere between the high and low levels observed in the normal state. Sympathetic denervation of the extremities, however, does not interfere with chemical and hormonal vasodilatation, which still takes place in muscles in response to exercise, local heating, and after the release of a tourniquet. These experiments, therefore, indicate that whenever the individual is cool or under certain types of strain, blood flow is decreased in the great mass of the muscles as well as in the skin. This is an added reason for extending the area of sympathetic denervation in hypertensive subjects through the diaphragm, so that the upper lumbar in addition to the lower thoracic ganglia can be removed and neurogenic vasoconstriction eliminated in the lower extremities as well as in the abdominal viscera.

According to Smithwick<sup>3, 62</sup> it seems clear that surgery has something worth while to offer the hypertensive patient. However, if consistent results are to be obtained, a radical denervation of the blood vessels in the lower half of the body must be carried out by removing the lower thoracic and upper lumbar sympathetic ganglia in addition to resecting the splanchnic nerves. The proof that this has been accomplished is established when there is a profound fall in blood pressure when the patient stands. It is obvious that when cardiac and renal functions are both significantly impaired no operation can be successful. Only an occasional patient over 50 years of age is suitable for operation. When the indications for operation are clearly defined, it is to be expected that a high percentage of patients will be benefited, as judged by persistent and significant lowering of blood pressure levels. Regression of eyeground changes, decrease in size of the heart, improvement in the electrocardiogram, increase in renal function, and relief of symptoms are noted. Time is beginning to show that life expectancy may be increased. This has certainly been true in cases of malignant hypertension and in patients with severe retinitis who have been submitted to adequate surgery before cardiac and renal functions have

been seriously impaired. Woods and Peet<sup>63</sup> have compared the post-operative survival rate of patients classified into four groups according to the severity of retinal changes with a similar control group treated medically, which has been described by Wagener and Keith.<sup>64</sup> In Group I (early hypertensives with normal fundi) the four patients operated upon were all alive at the end of five years, as against a 30 per cent incidence of mortality in the medically treated group. In Groups III and IV (with unmistakable angiospasm advancing to hemorrhages, exudates, and papilledema) the increased survival rate of the sympathectomized cases becomes very striking, as twenty-two out of thirty-three in Group III survived as against an 80 per cent mortality in the control group; and of the twenty-four patients in Group IV (with the malignant form of the disease), in which 88 per cent of the medically treated patients were dead at the end of eighteen months and only one survived for five years, one-half of the surgical group lived for over two years and one-third were alive after five years. In the Group II series, however, operation had no apparent effect on survival. This group was largely made up of cases of arteriolar sclerosis without angiospasm, and for these patients with high blood pressure, operation seemed to have little to offer. The outstanding need for more careful selection of cases is clearly shown in the statistics which have been reported by Rytaud and Holman.<sup>65</sup> They employed Peet's type of intrathoracic sympathectomy in some forty patients suffering from malignant hypertension and in others with congestive heart failure, coronary occlusion, local renal pathology, and nephritis, as well as in a few cases with the essential form of the disease. No attention was paid to the usual contraindications, and patients were operated upon at any age, with the result that a significant fall in blood pressure was obtained in only two cases.

The operations in current use for relief of hypertension vary considerably in extent. They fall into three main groups: (a) supra-diaphragmatic ganglionectomy and splanchnicectomy as employed by Peet and described by him and his colleagues,<sup>66, 67</sup> (b) the subdiaphragmatic operation of Allen and Adson,<sup>68</sup> and (c) the combined, more radical thoracolumbar denervation of Smithwick.<sup>69</sup> Both of the first two procedures are open to the objection that they do not completely denervate the lower half of the body, and it is furthermore very unlikely that the limited length of splanchnic fibers that can be removed from beneath the diaphragm is sufficient to prevent regeneration. In the postoperative results reported by Peet, 51 per cent of the patients developed a satisfactory reduction in blood pressure; in Adson's cases a similar improvement is reported in less than 40 per cent. But in Heuer and Glenn's<sup>70</sup> statistics the lasting reduction in blood pressure after these two procedures was far less impressive. The combined thoracolumbar approach of Smithwick<sup>69</sup> permits the removal of a great length



of the splanchnic trunks as well as of the ganglionated chains from the ninth thoracic down through the first or second lumbar segments. A most significant point is that, before adopting this somewhat more extensive procedure, Smithwick<sup>1</sup> had tried the more limited operations above and below the diaphragm. His results in these were not as satisfactory as those recorded in the reports of their advocates, but with the adoption of the combined operation in 1938, a significant improvement took place. In his last statistics, which were presented in the discussion of the article by de Takáts, Heuer, and Keeton,<sup>71</sup> Smithwick states that in his first series of thirty-eight patients followed from six months to two and one-half years, 71 per cent had a significant and persistent lowering of blood pressure. Even of the advanced patients in Groups III and IV, 60 per cent had a striking reduction in pressure. An outstanding feature of this operation is the striking fall in blood pressure when the patient stands. This orthostatic hypotension is of infrequent occurrence after operations of more limited extent above or below the diaphragm, and is a proof that the lower extremities as well as the abdominal viscera have been deprived of their normal vasoconstrictor tone.

Most impressive confirmation of the increased effectiveness of the more radical combined denervation has been given by de Takáts and his associates.<sup>19</sup> He states that in his hands supradiaphragmatic and infradiaphragmatic nerve sections gave only temporary results, or none at all; since adopting the combined more radical operation improvement has been achieved, not only in the patients with early and more moderately advanced disease, but also in those of Group III with retinal hemorrhages and detectable renal damage. The difficulty of comparing post-operative statistics of different surgeons in favor of a special procedure is well known, but when an impartial observer has given all a fair trial his conclusions are likely to have the greatest significance. Thoracolumbar sympathectomy is at the same time a more effective and a far less mutilating method of abolishing central vasoconstrictor tone in the caudal half of the body than cutting the corresponding anterior spinal roots. One reason for its greater effectiveness is that preganglionic fibers destined for the abdominal plexuses may leave the cord higher than its sixth thoracic segment, but these are interrupted when the paravertebral ganglia and splanchnic trunks are resected. Incomplete denervation probably accounts for the unimpressive late statistics of Heuer's cases treated by anterior rhizotomy.<sup>70</sup> Of these nineteen patients, all those who suffered from the malignant form of the disease died within three and three-quarters years. In the seven survivors with less severe forms of the disease, the blood pressure rose over a period of two to three years until it approached, but seldom reached, the preoperative level.

A further extension of surgical denervation to total sympathectomy has been advocated by Grimson.<sup>58, 72, 73</sup> In his preliminary experiments

with Wilson and Phemister<sup>74</sup> it was demonstrated that no operation short of total sympathectomy prevents the pressor response to neurogenic elevation of blood pressure which takes place on increasing intracranial pressure. These observations have been elaborated by Freeman and Jeffers,<sup>75</sup> who found that if the sympathetic denervation is extended upward to include the heart it will prevent the elevation of blood pressure produced by increased intracranial pressure. That various types of localized sympathetic denervation have not prevented neurogenic hypertension in dogs does not seem an adequate reason for adopting such an extensive operative procedure in man, unless the clinical results turn out to be far superior to the satisfactory and safe method of denervating the entire lower half of the body which has been proposed by Smithwick. The results reported by Grimson<sup>58</sup> have not as yet established his contention.

The mechanisms whereby sympathetic denervation of the abdominal viscera and lower extremities brings about a reduction in blood pressure, regression of retinal and renal changes, and relief of symptoms are still but poorly understood. It is particularly difficult to explain how improvement in the latter may come about when there is little or no lowering of the blood pressure. Recent studies on the correlation of vascular pathology observed in biopsy specimens taken from the kidneys and renal clearance in hypertensive patients treated by radical sympathectomy have cast doubt on the primary importance of reduced renal blood flow in the causation of the disease. These data, obtained by Talbott and his colleagues<sup>76</sup> in twenty hypertensive patients submitted to radical thoracolumbar sympathectomy by Smithwick, show "a significant correlation of renal clearance with the microscopic appearance of their respective renal tissues, i.e., the more severe the renal vascular disease, the more reduced were the glomerular filtration rate and the renal blood flow. In the cases with grade O and I renal vascular disease, the renal clearance observations were either normal or only very slightly reduced. Only in grade IV renal vascular disease was renal blood flow seriously reduced." It is therefore probable that the observations of Foà, Woods, Peet, and Foà,<sup>77</sup> which indicate that the effective renal blood flow in hypertensive patients is reduced nearly 50 per cent, must have been made in advanced cases of the disease, and Castleman and Smithwick's<sup>78</sup> examination of renal biopsies in 100 hypertensive patients has shown that vascular disease was absent or insignificant in 28 per cent and distinctly mild in an additional 25 per cent. From these observations they conclude that morphologic evidence of renal vascular disease in more than one-half these cases is inadequate to be the sole factor in producing the hypertension. It would seem more likely that in most instances the hypertensive state antedates the renal vascular lesion, although the latter, once established, may aggravate the hypertension.

The renal clearance determinations of Talbott and co-workers<sup>76</sup> and a number of other independent investigators<sup>79, 80, 81</sup> have shown beyond a doubt that sympathectomy does not bring about any increase in the basal rate of blood flow through the hypertensive kidney. However, Smithwick<sup>3</sup> has suggested that the operation may eliminate reflex constriction of the afferent renal arterioles, such as occurs whenever the individual assumes the upright posture. Furthermore, with the reduction of adrenal secretion by medullary denervation, constriction of the efferent renal arterioles must be decreased.

In conclusion, it must be stated that the most reasonable explanation for the decrease of arterial pressure which follows sympathectomy in hypertensive patients is the general reduction of the tone of smooth muscle in the denervated vascular bed (Smithwick).<sup>3</sup> The explanation offered by Coreoran and Page,<sup>80</sup> that there is a partial failure of venous return, seems much less likely since it applies only to the postural hypotension seen in the acutely denervated state. It does not account for the persistent lowering of blood pressure in the horizontal position which is generally associated with a lowering of the heart rate. While other methods for reducing high blood pressure, such as antipressor substances, may ultimately be developed, thoracolumbar splanchnicectomy with removal of the lower thoracic and upper lumbar sympathetic ganglia appears to be the most effective method of treatment known at present. Although it is not yet established that the results will be permanent, at least there is good reason to believe that the hands of the clock can be set back for a number of years in the majority of younger patients with hypertension who have not been permitted to progress to the stage of advanced degenerative changes in the arteries of the kidney, heart, and brain.

#### GASTROINTESTINAL TRACT

Knight's<sup>82</sup> experimental work with achalasia (cardiospasm) has shown that in the cat there exists a true sphincter mechanism at the cardiac end of the esophagus; that bilateral vagotomy reproduces the appearance of achalasia, and that sympathectomy prevents it. Because in dissection of cadavers it was found that the sympathetic nerve supply to the cardia is derived chiefly from the left side of the celiac plexus and distributed along the left gastric artery, Knight advocated excision of this artery with its surrounding plexus of nerves. Ochsner and DeBakey,<sup>83</sup> in their surgical considerations of achalasia, have collected nineteen instances in which this procedure has been employed, including one case of their own. The results in these were not impressive, there being partial improvement in only four. Mitchell,<sup>84, 85</sup> who has worked out the innervation of the stomach in the most minute detail, expressed the opinion that the high incidence of recurrence may be due to the great anatomic variation in the sympathetic fibers to this region.

In the broader experience with sympathetic denervation it is certainly true that the results are unsatisfactory unless the interruption of fibers has been anatomically complete.

While enthusiasm for treating congenital megacolon by sympathectomy has waned, considerable progress has been made in treating this condition by parasympathetic drugs. Law<sup>86</sup> points out that children below the age of 4 stand the necessarily extensive operation of surgical denervation poorly, and that in older patients, with marked colonic dilatation and a thin, weak musculature, operation is not often successful. He believes that parasympathetic stimulation, rather than a block of the sympathetic inhibitor axones, may be the best therapy. Parasympathetic stimulation affects the colon and its sphincters as a functional unit by causing contraction of the former and relaxation of the latter. The earliest parasympathomimetic drug to be produced was acetylcholine, but this is rapidly destroyed in the body by cholinesterase. Acetyl-beta-methylcholine chloride is more stable, but it must be given by injection and it is difficult to adjust the dosage to produce evacuation without causing toxic symptoms. The bromide, however, is more stable and may be given by mouth in doses of from 0.1 to 0.2 Gm. after breakfast and, if necessary, in midafternoon. Law reviews the successful treatment of six children suffering from Hirschsprung's disease with oral dosage of acetyl-beta-methylcholine bromide and liquid petrolatum. Two of these patients were able to discontinue the drug after three to nine months of treatment. A second corroborative report has been made by Barenberg, Greene, and Greenspan,<sup>87</sup> who have described a child with congenital dilatation of the colon observed continuously from the age of 3 months for four and one-half years. During this period the effects of various medical procedures, drugs, and surgery (an incomplete sympathectomy of the rectum and lower colon) were studied. The best results were obtained with the oral administration of mecholyl bromide (in the dosage given by Law) and mineral oil. The patient has been completely relieved of abdominal distension as well as constipation, and his physical development is progressing in a normal manner.

A much more common and acute form of intestinal atony is the distension which follows laparotomy. This is caused by reflex depression of the parasympathetic division of the autonomic nervous system. For its relief and, better still, its prevention, Gordon<sup>88</sup> recommends the postoperative administration of the parasympathetic stimulant, prostigmine, and reviews the previous articles which have appeared on this subject since 1931. The incidence and severity of postoperative abdominal distension were reduced in cases in which 1 c.c. of prostigmine methylsulfate 1:4000 solution (prostigmine prophylactic) was injected subcutaneously at intervals of four, six, or eight hours or more during the first three days after operation. The drug should, of course, not

be employed in cases of peritoneal infection or bowel obstruction, but it is claimed that patients who would not require the use of a cholinergic drug are not harmed thereby, and that postoperative intestinal distension is more easily prevented than treated.

While surgical interruption of the abdominal sympathetic fibers for visceromotor disorders is being regarded with diminishing enthusiasm, its value for the control of pain from various abdominal organs has been emphasized by White and Smithwick.<sup>1</sup> Examples are recorded of effective relief of intractable pain in: (a) metastatic carcinoma of the liver treated by paravertebral infiltration of alcohol around the six lowest thoracic ganglia on the right side, in a patient whose general condition contraindicated cordotomy; (b) penetrating ulcer of the posterior wall of the duodenum in two patients relieved by similar injections, where advanced coronary disease prevented a direct surgical attack; (c) pain secondary to postoperative atresia of the biliary ducts, and also peristaltic pain of unknown origin, relieved by splanchnicectomy and resection of the upper lumbar sympathetic ganglia. Although suitable cases of chronic abdominal pain for localized denervation must necessarily be rare, operations of this type are distinctly less mutilating and less subject to complications than section of the spinothalamic tracts. The outcome can be tested in advance by diagnostic procaine block, and patients with underlying cardiac or malignant disease who could tolerate no open operation can often be given satisfactory relief for the duration of their lives by destroying the sympathetic rami with alcohol.

#### POST-TRAUMATIC PAIN IN THE EXTREMITIES

Why certain causalgias, painful amputation stumps, and post-traumatic dystrophies (Sudeek's atrophy) should respond to sympathetomy and even to injection of procaine is yet to be explained. With the increasing number of cases reported it is evident that the response is often dramatic, and that sympathetomy is most likely to be effective when the blood vessels of the extremity are in a state of chronic vasodilatation or constriction. Similarly, it is apparent that the procedure is most often successful when the hand or foot is involved, and that few instances have been reported where pain above the elbow or knee has been relieved. These points suggest that sympathetic vasomotor reflexes are concerned and that their surgical or chemical block interrupts the efferent half of a reflex arc.

The underlying physiologic mechanisms have been reviewed by Miller and de Takáts.<sup>89</sup> It is possible that the painful stimuli which set up vasomotor reflexes travel centripetally through the sympathetic fibers. Atlas<sup>90</sup> has recently described a case where, after injury to the roots of the cauda equina, only the sympathetic nerve supply to the leg appeared to remain intact. This patient had a very cold, cyanotic, sweaty foot which was anesthetic but extremely painful. As the pain

disappeared after the sympathetic outflow was blocked, he concluded that the painful sensations must have originated in the blood vessels and that they reached the cord over sympathetic pathways. Hyndman and Wolkin<sup>91</sup> have also described two cases in which compression fractures of the second lumbar vertebrae had caused characteristic sensory-motor paralysis of the legs without interrupting sympathetic innervation. In both these patients some degree of sensory perception was retained, which the authors conclude must have been transmitted over sympathetic pathways. In addition, they observed that a sympathectomy greatly diminishes the aching, stinging pain of the hands and feet that results from exposure to cold. Heretofore, with the exception of Foerster and Leriche, all experimental and clinical investigators have denied that any afferent impulses from the extremities are carried by the sympathetic nervous system. It is possible that the pain in these extremely interesting cases may have reached the central nervous system over somatic fibers which remained intact in the deeper structures. A second hypothesis which has been suggested by Miller and de Takáts is that sympathectomy, by accelerating circulation, washes out a "pain substance" which has been described by Sir Thomas Lewis in his recent monograph on pain.<sup>92</sup>

Many impressive case reports have appeared in the last three years describing the encouraging response to surgical or chemical interruption of the sympathetic pathways. In cases of ligamentous sprains and periarticular contusions with vasomotor disturbances of the type leading to Sudeek's atrophy, the largest series has been assembled by Miller and de Takáts;<sup>89</sup> other valuable reports have been contributed by Atlas<sup>90</sup> and by Mahorner.<sup>93</sup> Further instances of intractable pain in the extremities have been classified as "minor causalgias" by Homans,<sup>94</sup> who emphasizes the effectiveness of the simpler procedures, such as repeated injection of procaine into a localized source of pain (as originally advocated by Leriche and Livingston) or infiltration of the stellate or upper lumbar sympathetic ganglia. White and Smithwick<sup>95</sup> have stated that if a favorable response is obtained with procaine, treatment by repeated injections should be given a thorough trial. Occasionally a single injection results in long-lasting relief. If relief is complete, but short-lived, sympathetic ganglionectomy is the procedure of choice. A favorable response may be expected when the extremity is cold, discolored, and moist, especially when the patient is benefited by local heat or fever therapy. Sympathectomy is also more likely to succeed in peripheral lesions, such as those which involve a finger, wrist, or foot, than when the pain comes from the shoulder or above the knee.

#### RELIEF OF PAIN IN ANGINA PECTORIS

The anatomy of the pain-carrying fibers from the heart is now so well understood<sup>3</sup> that sensory denervation can be counted upon to

relieve the suffering of angina pectoris in patients who have failed to respond to medical treatment. The effectiveness of cutting the upper four thoracic posterior spinal roots (Haven and King,<sup>95</sup> Ray<sup>96</sup>) or resecting the upper three thoracic sympathetic ganglia (White and Smithwick<sup>3</sup>), through which the sensory axones run, has been found to approach 100 per cent. In patients who are good enough operative risks to withstand these procedures there is no evidence that relief from pain has any but a favorable effect, and an adequate warning signal has not been lost. Unfortunately, the selection of suitable cases for these operations is not easy, and many of the worst sufferers have too poor a coronary circulation to withstand any major surgical procedure. For these, chemical destruction of the cardiac sensory fibers, as they traverse the upper thoracic sympathetic ganglia and their rami before joining the spinal nerves, is a fairly satisfactory substitute. The technique of paravertebral injection has been reported in detail by White.<sup>97</sup> More than sixty additional cases treated in this manner have been reported by Perlow<sup>98</sup> and by Levy and Moore.<sup>99</sup> Satisfactory relief is recorded in 73 per cent and 77.5 per cent, respectively, of their patients without a single death. In the latter series relief was marked and permanent in 47.5 per cent of the total number; eight of these have been followed for more than six years, two for nine years. Many of the patients who had been bedridden or confined to the house were able to resume an active life. Changes in the form of the electrocardiogram in the direction of normal suggest that interruption of the sensory pathways in certain cases may diminish or abolish spasm in the coronary bed. Levy and Moore conclude on the basis of this evidence, and in view of experiments on dogs by McEachern, Manning, and Hall,<sup>100a</sup> that it is probable that interruption of pathways for pain may exert a beneficial effect on the coronary circulation.

The treatment of intractable angina pectoris by sclerosing solutions injected at the sides of the upper thoracic vertebrae is open to the objections that it fails to produce an effective nerve block in some 25 per cent of cases, that it is usually followed by a varying degree of neuritis, and that it has on rare occasions resulted in injury to the spinal cord. The chemical irritation of the intercostal nerves cannot be avoided, but is a source of serious complaint in only 10 per cent and almost never lasts more than a few weeks. Complications from direct trauma to the cord in the course of paravertebral injection or from alcohol entering the subarachnoid space have been reported by Olsen<sup>102</sup> and by Hirschboeck and Gillespie.<sup>103</sup> In these, a typical Brown-Séquard paralysis developed instantaneously, which in one of Olsen's cases has lasted eighteen years. To avoid this most serious accident, White<sup>97</sup> recommended inserting the needles at least 3 cm. anterior to the transverse processes

\*These investigators found that removal of cardiosensory pathways eliminates the pain and markedly reduces the mortality rate after sudden occlusion of the larger branches of the left coronary artery in the conscious dog. Although Yodanis<sup>101</sup> has questioned these results, the more refined experimental technique of the Canadian workers makes me favor their contention.

(well anterior to the intervertebral foramina and spinal nerves), preliminary injection of procaine, and very slow infiltration of alcohol with frequent testing for evidence of spinal block. In experienced hands the treatment of severe angina pectoris with advanced coronary disease can be undertaken with minimum risk and with better than three chances out of four of securing satisfactory reduction in the severity and frequency of the attacks. In one-half the cases all pain will be abolished on the injected side. But when injection has failed or the patient's more favorable condition permits, surgical interruption of the nerves is unquestionably the procedure of choice.

#### SENSORY-MOTOR INNERVATION OF UROGENITAL TRACT

The most important work to be published on bladder innervation during the past three years is the monograph by Langworthy, Kolb, and Lewis.<sup>104</sup> Their investigations overthrow the older theory of antagonism between the sympathetic and parasympathetic innervations of the bladder and its sphincters. The sympathetic is confined to vasomotor supply and sexual functions (vesical neck, prostate, and seminal vesicles), and its activity is not essential to normal micturition. Stimulation of the sacral roots which contain the parasympathetic fibers produces contraction and emptying of the bladder. Micturition begins with a contraction of the bladder musculature, and only after the intravesical pressure rises does the internal sphincter open. The external sphincter opens later. This also is an involuntary act, and the only voluntary power of the so-called "voluntary" sphincter is to contract and postpone or stop urination. The clinical manifestations that are found after nerve lesions have been correlated with the functional levels of the central nervous system in a most logical manner by Evans.<sup>105</sup> Beginning at the highest level in the cortex, there is the fully integrated mechanism of micturition subject to inhibition by the person who can suppress the desire to void or who can initiate micturition at will. At the next lower level of function in the brain stem micturition occurs subconsciously, but may still be well coordinated. At the spinal level, following recovery from shock, a fairly well-coordinated activity may develop in time, but urination is mediated by spinal reflexes whenever the intravesical pressure becomes elevated and is therefore explosive in nature. Finally, there is the poorly coordinated, totally inefficient type of micturition seen in the isolated bladder after lesions of the cauda equina or pelvic nerves. Clinical examples after various neurogenic lesions and their interpretation by the cystometrogram are given in the monograph by McLellan.<sup>106</sup> Unfortunately, all this recent knowledge goes to show that sympathetic denervation is of no value in the treatment of the paralyzed bladder.

The same is largely true of the painful bladder, as the great majority of its sensory fibers run in the sacral nerves. Resection of the superior hypogastric plexus (presacral nerves) in no way alters the patient's



sensation as the bladder is filled.<sup>2</sup> In the few convincing cases where presacral neurectomy has reduced bladder pain, McLellan<sup>106</sup> believes that its action is through reduction of spasm in the vesical neck and trigone, areas which are innervated by the sympathetic.

In contrast to the bladder, sensory fibers from the kidney and ureter pass in large part through the sympathetic renal and splanchnic plexuses to enter the spinal cord over its lowest thoracic and upper lumbar roots.<sup>3</sup> Gunnar Bauer<sup>107</sup> reported eleven patients with renal pain, in whom denervation by sympathetomy produced relief. The pain had been present for long periods, and the operation was followed by no serious complications.

The recent application of high caudal anesthesia to obstetrics by Edwards and Hingson<sup>108</sup> has demonstrated that all sensory nerves from the uterus enter the spinal cord below its tenth thoracic segment. This goes back to the classical work on uterine innervation by Cleland,<sup>109</sup> in which he showed that the uterus derives its sensory nerve supply from two sources, the fibers to the fundus arising from the eleventh and twelfth thoracic spinal segments and passing through the preaortic and superior hypogastric plexuses, while the sensory fibers to the cervix are found in the parasympathetic plexus of sacral nerves. After presacral neurectomy, biopsies may be taken painlessly from the body of the uterus, but the cervix and tubes remain sensitive.<sup>3</sup> The nerve supply to the latter comes from the ovarian plexuses and descends along the ureters. The anatomic arrangement of the pelvic autonomic nerves has been described and clearly illustrated by Curtis, Anson, Ashley, and Jones.<sup>110</sup> While resection of the superior hypogastric plexus remains a satisfactory method of dealing with the most intractable cases of idiopathic dysmenorrhea, there have been no successful new applications of this method to report.

#### REFERENCES

1. White, J. C.: Progress in Surgery of the Autonomic Nervous System in 1938 and 1939, *SURGERY* 9: 115-131, 1941.
2. Hare, K., and Hinsey, J. C.: The Autonomic Nervous System, *Ann. Rev. Physiol.* 4: 407-444, 1942.
3. White, J. C., and Smithwick, R. H.: The Autonomic Nervous System: Anatomy, Physiology, and Surgical Application, ed. 2, New York, 1941, The Macmillan Company, 469 pp.
4. Fulton, J. F.: Les niveaux centraux de la fonction autonome, avec relations particulières avec les organes endocriniens, *Rev. neurol.* 72: 360-361, 1939-40.
5. The Hypothalamus and Central Levels of Autonomic Function (Research Publ. A. Nerv. & Ment. Dis., vol. XX), Baltimore, 1940, Williams & Wilkins Company, pp. 980.
6. Cannon, W. B., and Britton, S. W.: Studies on the Conditions of Activity in Endocrine Glands: XV. Pseudoaffective Medulladrenal Secretion, *Am. J. Physiol.* 72: 283-313, 1925.
7. Wortis, H., and Maurer, W. S.: "Sham Rage" in Man, *Am. J. Psychiat.* 98: 638-644, 1942.
8. Sjöqvist, O.: Hypothalamic Discharge and Its Relation to Epilepsy, With the Report of a Case of "Sham Rage" in Man With Surgical Verification, *Acta chir. Scandinav.* 85: 235-247, 1941.
9. Penfield, W.: Diencephalic Autonomic Epilepsy, *Arch. Neurol. & Psychiat.* 22: 358-374, 1929.

10. Masserman, J. H.: Is the Hypothalamus the Seat of Emotion? (Trans. Chicago Neurol. Soc.) Arch. Neurol. & Psychiat. 45: 896, 1941.
11. Globus, J. H.: Probable Topographic Relations of the Sleep-Regulating Center, Arch. Neurol. & Psychiat. 43: 125-138, 1940.
12. Duthie, J. J. R., and Mackay, R. M. I.: Vasomotor Reflexes in the Control of Body Temperature in Man, Brain 63: 295-320, 1940.
13. Langley, J. N.: On the Origin From the Spinal Cord of the Cervical and Upper Thoracic Sympathetic Fibers, With Some Observations on White and Grey Rami Communicantes, Philos. Trans., s. B. 183: 85-124, 1892.
14. Sheehan, D.: Spinal Autonomic Outflows in Man and Monkey, J. Comp. Neurol. 75: 341-370, 1941.
15. Sheehan, D., and Marrazzi, A. S.: Sympathetic Preganglionic Outflow to Limbs of Monkeys, J. Neurophysiol. 4: 68-79, 1941.
16. Geohagan, W. A., Wolf, G. A., Jr., Aidar, O. J., Hare, K., and Hinsey, J. C.: The Spinal Origin of the Preganglionic Fibers to the Limbs in the Cat and Monkey, Am. J. Physiol. 135: 324-329, 1942.
17. Kuntz, A., and Dillon, J. B.: Preganglionic Components of the First Thoracic Nerve: Their Role in the Sympathetic Innervation of the Upper Extremity, Arch. Surg. 44: 772-778, 1942.
18. Kirgis, H. D., and Kuntz, A.: Inconstant Sympathetic Neural Pathways: Their Relation to Sympathetic Denervation of the Upper Extremity, Arch. Surg. 44: 95-102, 1942.
19. Scapham, G. W., de Takáts, G., Van Dellen, T. R., and Jesser, J. H.: Vascular Diseases: Seventh Annual Review, Arch. Int. Med. 68: 599-660, 1941.
20. Homans, J.: Vascular Disorders of the Extremities, New England J. Med. 226: 917-922, 1942.
21. Lewis, T.: Vascular Disorders of the Limbs Described for Practitioners and Students, New York, 1936, The Macmillan Company, 111 pp.
22. Barker, N. W., and Baker, G. S.: Acrocyanosis: Effect of Cervicothoracic Sympathectomy: Report of a Case, Proc. Staff Meet., Mayo Clin. 15: 601-604, 1940.
23. Hyndman, O. R., and Wolkin, J.: Raynaud's Disease: A Review of Its Mechanism, with Evidence that It Is Primarily a Vascular Disease, Am. Heart J. 23: 535-554, 1942.
24. Johnson, C. A.: A Study of the Clinical Manifestations and the Results of Treatment of Twenty-Two Patients With Raynaud's Symptoms, Surg., Gynec. & Obst. 72: 889-907, 1941.
25. Smithwick, R. H.: Surgical Intervention on the Sympathetic Nervous System for Peripheral Vascular Disease, Arch. Surg. 40: 286-306, 1940.
26. Learmonth, J. R.: The Surgery of the Sympathetic Nervous System, Brit. J. Surg. 25: 426-445, 1937.
27. Atlas, L. N.: Further Observations on the Etiology of Vasomotor Disturbances Following Peripheral Nerve Section, SURGERY 10: 318-322, 1941.
28. Ochsner, A., and DeBakey, M.: Peripheral Vascular Disease: A Critical Survey of Its Conservative and Radical Treatment, Surg., Gynec. & Obst. 70: 1058-1072, 1940.
29. Smithwick, R. H.: The Problem of Producing Complete and Lasting Sympathetic Denervation of the Upper Extremity by Preganglionic Section, Ann. Surg. 112: 1085-1100, 1940.
30. Atlas, L. N.: The Role of the Second Thoracic Spinal Segment in the Preganglionic Sympathetic Innervation of the Human Hand—Surgical Implications, Ann Surg. 114: 456-461, 1941.
31. Hyndman, O. R., and Wolkin, J.: Sympathectomy of the Upper Extremity: Evidence that Only the Second Dorsal Ganglion Need Be Removed for Complete Sympathectomy, Arch. Surg. 45: 145-155, 1942.
32. Geohagan, W. A., and Aidar, O. J.: Functional Reorganization After Preganglionectomy, Proc. Soc. Exper. Biol. & Med. 50: 365-369, 1942.
33. Ray, B. S., Hinsey, J. C., Hare, K., and Geohagan, W. A.: The Origin of Preganglionic Sympathetic Fibers to the Pupil and Upper Limb in Man, Tr. Am. Neurol. A. 1942: 51-54.
34. Sheehan, D.: The Autonomic Nervous System, Ann. Rev. Physiol. 1941.
35. Fatherree, T. J., Adson, A. W., and Allen, E. V.: The Vascular Action of Epinephrine on the Digital Arterioles of Man Before Sympathectomy, SURGERY 7: 75-94, 1940.

36. Ascroft, P. B.: The Basis of Treatment of Vasospastic States of the Extremities: An Experimental Analysis in Monkeys. *Brit. J. Surg.* 24: 787-816, 1937.
37. Leriche, R., and Kunlin, J.: Traitement immédiat des phlébites post-opératoires par l'infiltration novocaïnique du sympathique lombaire, *Presse méd.* 42: 1481-1482, 1934.
38. Ochsner, A., and DeBakey, M.: Thrombophlebitis: The Role of Vasospasm in the Production of the Clinical Manifestations, *J. A. M. A.* 114: 117-123, 1940; Therapy of Phlebothrombosis and Thrombophlebitis, *Arch. Surg.* 40: 208-231, 1940.
39. Telford, E. D., and Simmons, H. T.: Erythromelalgia, *Brit. M. J.* 2: 782, 1940.
40. Freeman, N. E., and Montgomery, H.: Lumbar Sympathectomy in the Treatment of Intermittent Claudication: Selection of Cases by Claudication Test with Lumbar Paravertebral Procaine Injection, *Am. Heart J.* 23: 224-242, 1942.
41. Learmonth, J. R.: The Surgery of Blood Vessels, *Edinburgh M. J.* 47: 225-240, 1940.
42. Veal, J. R.: The Value of Sympathetic Interruption Following Surgical Repair of Peripheral Aneurysms, *M. Ann. District Columbia* 9: 227-230, 1940.
43. Richards, R. L., and Learmonth, J. R.: Lumbar Sympathectomy in Treatment of Popliteal Aneurysm, *Lancet* 242: 383-384, 1942.
44. Atlas, L. N.: A Complicated Case of Aneurysm Involving the Iliac and Femoral Arteries, *Ann. Surg.* 116: 708-712, 1942.
45. Gage, M.: Arterial Aneurysm of the Peripheral Arteries: Methods of Developing the Collateral Circulation, *Tr. South. S. A.* 52: 257-268, 1940; The Development of the Collateral Circulation in Peripheral Arterial Aneurysms by Sympathetic Block, *SURGERY* 7: 792-795, 1940.
46. Leriche, R.: De la résection du carrefour aortico-iliaque avec double sympathectomie lombaire pour thrombose artérielle de l'aorte; le syndrome de l'oblitération terminale-aortique par artérite, *Presse méd.* 48: 601-604, 1940.
47. Telford, E. D.: Cervical Rib and Hyperhidrosis, *Brit. M. J.* 2: 96, 1942.
48. Gurney, R., and Bunnell, I. L.: A Study of the Reflex Mechanism of Sweating in the Human Being; Effect of Anesthesia and Sympathectomy, *J. Clin. Investigation* 21: 269-274, 1942.
49. Hyndman, O. R., and Wolkin, J.: Sweat Mechanism in Man: Study of Distribution of Sweat Fibers From the Sympathetic Ganglia, Spinal Roots, Spinal Cord and Common Carotid Artery, *Arch. Neurol. & Psychiat.* 45: 446-467, 1941.
50. Hyndman, O. R., and Wolkin, J.: The Pilocarpine Sweating Test: I. A Valid Indicator in Differentiation of Preganglionic and Postganglionic Sympathectomy, *Arch. Neurol. & Psychiat.* 45: 992-1006, 1941.
51. Richter, C. P., and Woodruff, B. G.: Changes Produced by Sympathectomy in the Electrical Resistance of the Skin, *SURGERY* 10: 957-970, 1941.
52. Mulholland, J. H., and Rovenstine, E. A.: Surgery in the Carotid Sinus Syndrome, *SURGERY* 9: 751-757, 1941.
53. Ray, B. S., and Stewart, H. J.: Observations and Surgical Aspects of the Carotid Sinus Reflex in Man, *SURGERY* 11: 915-938, 1942.
54. Romano, J., Stead, E. A., Jr., and Taylor, Z. E.: Clinical and Electroencephalographic Changes Produced by a Sensitive Carotid Sinus of the Cerebral Type, *New England J. Med.* 223: 708-712, 1940.
55. Leger, L.: Le Danger Sinu-Carotidien des Interventions Cervicales, *Presse méd.* 48: 451-453, 1940.
56. Weese, H.: Mechanism of Anesthesia Accidents Following Intravenous Use of Evipal Soluble, Barbitol Derivative, in Sublingual Phlegmons (Rôle of Carotid Sinus), *Anesth. & Analg.* 18: 15-21, 1939.
57. Ruzicka, E. R., and Eversole, U. H.: The Carotid Sinus in Anesthesiology: Report of Two Cases, *Lahey Clin. Bull.* 3: 47-54, 1942.
58. Grimson, K. S.: The Surgical Treatment of Hypertension: Collective Review, *Internat. Abstr. Surg. (Surg., Gynec. & Obst.)* 75: 421-434, 1942.
59. Wilkins, R. W., and Eichna, L. W.: Blood Flow to the Forearm and Calf: I. Vasomotor Reactions: Rôle of the Sympathetic Nervous System, *Bull. Johns Hopkins Hosp.* 68: 425-449, 1941.
60. Eichna, L. W., and Wilkins, R. W.: Blood Flow to the Forearm and Calf: II. Reactive Hyperemia: Factors Influencing the Blood Flow During the Vasodilatation Following Ischemia, *Bull. Johns Hopkins Hosp.* 68: 450-476, 1941.

61. Wilkins, R. W., and Eichna, L. W.: Blood Flow to the Forearm and Calf: III. The Effect of Changes in Arterial Pressure on the Blood Flow to Limbs Under Controlled Vasodilatation in Normal and Hypertensive Subjects, *Bull. Johns Hopkins Hosp.* 68: 477-511, 1941.
62. Smithwick, R. H.: Surgery of the Autonomic Nervous System: Method of Study, with Particular Reference to the Interpretation of Clinical Results, *New England J. Med.* 226: 605-612, 1942.
63. Woods, W. W., and Peet, M. M.: The Surgical Treatment of Hypertension: II. Comparison of Mortality Following Operation With That of the Wagener-Keith Medically Treated Control Series: A Study of Seventy-Six Cases From Five to Seven Years After Operation, *J. A. M. A.* 117: 1508-1515, 1941.
64. Wagener, H. P., and Keith, N. M.: Diffuse Arteriolar Disease With Hypertension and the Associated Retinal Lesions, *Medicine* 18: 317-430, 1939.
65. Rytand, D. A., and Holman, E.: Arterial Hypertension and Section of Splanchnic Nerves, *Arch. Neurol. & Psychiat.* 47: 1052-1053, 1942.
66. Peet, M. M., Woods, W. W., and Braden, S.: The Surgical Treatment of Hypertension: Results in 350 Consecutive Cases Treated by Bilateral Supradiaphragmatic Splanchnicectomy and Lower Dorsal Sympathetic Ganglionectomy, *J. A. M. A.* 115: 1875-1885, 1940.
67. Woods, W. W.: The Surgical Treatment of Hypertension: Results of Clinical and Experimental Investigations, *J. Urol.* 48: 16-22, 1942.
68. Allen, E. V., and Adson, A. W.: The Treatment of Hypertension; Medical Versus Surgical, *Ann. Int. Med.* 14: 288-307, 1940.
69. Smithwick, R. H.: A Technique for Splanchnic Resection for Hypertension: Preliminary Report, *SURGERY* 7: 1-8, 1940.
70. Heuer, G. J., and Glenn, F.: An Evaluation of the Surgical Treatment of Hypertension, *New York State J. Med.* 41: 1922-1926, 1941.
71. de Takáts, G., Heyer, H. E., and Keeton, R. W.: The Surgical Approach to Hypertension, *J. A. M. A.* 118: 501-507, 1942.
72. Grimson, K. S.: Total Thoracic and Partial to Total Lumbar Sympathectomy and Celiac Ganglionectomy in the Treatment of Hypertension, *Ann. Surg.* 114: 753-775, 1941.
73. Grimson, K. S.: The Sympathetic Nervous System in Neurogenic and Renal Hypertension: Experimental Correlation and Clinical Consideration, *Arch. Surg.* 43: 284-305, 1941.
74. Grimson, K. S., Wilson, H., and Phemister, D. B.: The Early and Remote Effects of Total and Partial Paravertebral Sympathectomy on Blood Pressure: An Experimental Study, *Ann. Surg.* 106: 801-825, 1937.
75. Freeman, N. E., and Jeffers, W. A.: Effect of Progressive Sympathectomy on Hypertension Produced by Increased Intracranial Pressure, *Am. J. Physiol.* 128: 662-671, 1940.
76. Talbott, J. H., Castleman, B., Smithwick, R. H., Melville, R. S., and Pecora, L. J.: Renal Biopsy Studies Correlated with Renal Clearance Observations in Hypertensive Patients Treated by Radical Sympathectomy, *J. Clin. Investigation* 22: 387-394, 1943.
77. Poà, P. P., Woods, W. W., Peet, M. M., and Foà, N. L.: Effective Renal Blood Flow, Glomerular Filtration Rate and Tubular Excretory Mass in Arterial Hypertension, *Arch. Int. Med.* 69: 822-835, 1942.
78. Castleman, B., and Smithwick, R. H.: The Relation of Vascular Disease to the Hypertensive State, Based on a Study of Renal Biopsies from One Hundred Hypertensive Patients, *J. A. M. A.* 121: 1256-1261, 1943.
79. Alving, A. S., Adams, W., Grimson, K. S., Scott, C., and Sandiford, I.: The Effect of Bilateral Sympathectomy on the Cardiorenal System in Essential Hypertension, *Proc. Central Soc. Clin. Research* 13: 39, 1940.
80. Corcoran, A. C., and Page, I. H.: Renal Blood Flow and Sympathectomy in Hypertension, *Arch. Surg.* 42: 1072-1082, 1941.
81. Findley, T., Clinton, E., and Edwards, J. C.: The Effect of Sympathectomy on Renal Blood Flow in Essential Hypertension, *SURGERY* 12: 64-67, 1942.
82. Knight, G. C.: The Relation of the Extrinsic Nerves to the Functional Activity of the Oesophagus, *Brit. J. Surg.* 22: 155-168, 1934; Sympathectomy in the Treatment of Achalasia of the Cardia, *Ibid.* 22: 864-876, 1935.
83. Ochsner, A., and DeBakey, M.: Surgical Considerations of Achalasia: Review of the Literature and Report of Three Cases, *Arch. Surg.* 41: 1146-1183, 1940.
84. Mitchell, G. A. G.: The Nerve Supply of the Gastro-Oesophageal Junction, *Brit. J. Surg.* 26: 333-345, 1938.

85. Mitchell, G. A. G.: A Macroscopic Study of the Nerve Supply of the Stomach, *J. Anat.* 75: 50-63, 1940.
86. Law, J. L.: The Treatment of Megacolon with Parasympathetic Drugs, *J. A. M. A.* 114: 2537-2540, 1940.
87. . . . ., Greene, D., and Greenspan, L.: Congenital Megacolon (Disease), Report of a Case Treated with Acetylbetamethyl-  
With Apparent Cure, *J. Pediat.* 18: 579-586, 1941.
88. Gordon, E. J.: The Treatment of Postoperative Abdominal Distention With Prostigmin, *SURGERY* 7: 686-695, 1940.
89. Miller, D. S., and de Takáts, G.: Posttraumatic Dystrophy of the Extremities: Sudeck's Atrophy, *Surg., Gynec. & Obst.* 75: 558-582, 1942.
90. Atlas, L. N.: Traumatic Vasospastic Dystrophy of the Extremities, *Arch. Surg.* 42: 1042-1047, 1941.
91. Hyndman, O. R., and Wolkin, J.: The Sympathetic Nervous System: Influence on Sensibility to Heat and Cold and to Certain Types of Pain, *Arch. Neurol. & Psychiat.* 46: 1006-1016, 1941.
92. Lewis, T.: Pain, New York, 1942, The Macmillan Co., 192 pp.
93. Mahorner, H.: Sympathetic Nerve Blocks in Rehabilitation of the Injured Extremity. Report of Cases; and a Discussion of Causalgia, *New Orleans M. & S. J.* 94: 426-432, 1942.
94. Homans, J.: Minor Causalgia: A Hyperesthetic Neurovascular Syndrome, *New England J. Med.* 222: 870-874, 1940; Minor Causalgia Following Injuries and Wounds, *Ann. Surg.* 113: 932-941, 1941.
95. Haven, H., and King, R. L.: Section of the Posterior Roots for the Relief of Pain in Angina Pectoris: Observations in Five Cases, *Surg., Gynec. & Obst.* 75: 208-219, 1942.
96. Ray, B. S.: The Management of Intractable Pain by Posterior Rhizotomy, *Research Publ. A. Nerv. & Ment. Dis.* 23: 391-407, 1943.
97. White, J. C.: Technique of Paravertebral Alcohol Injection: Methods and Safeguards in Its Use in the Treatment of Angina Pectoris, *Surg., Gynec. & Obst.* 71: 334-343, 1940.
98. Perlow, S.: Paravertebral Alcohol Injection for Relief of Cardiac Pain, *Illinois M. J.* 81: 35-41, 1942.
99. Levy, R. L., and Moore, R. L.: Paravertebral Sympathetic Block With Alcohol for the Relief of Cardiac Pain: Report of Forty-five Cases, *J. A. M. A.* 116: 2563-2568, 1941.
100. McEachern, C. G., Manning, G. W., and Hall, G. E.: Sudden Occlusion of Coronary Arteries Following Removal of Cardiosensory Pathways: An Experimental Study, *Arch. Int. Med.* 65: 661-670, 1940.
101. Yodice, A.: Sympathectomy and Experimental Occlusion of a Coronary Artery, *Am. Heart J.* 22: 545-548, 1941.
102. Olsen, C. W.: Injury to the Spinal Cord and Spinal Nerve Roots in the Course of Paravertebral Injection, *Bull. Los Angeles Neurol. Soc.* 6: 131-134, 1941.
103. Hirschboeck, F. J., and Gillespie, M. G.: A Complication of Paravertebral Injection of Alcohol: Report of a Case, *Arch. Neurol. & Psychiat.* 48: 320-322, 1942.
104. Langworthy, O. R., Kolb, L. C., and Lewis, L. G.: Physiology of Micturition: Experimental and Clinical Studies With Suggestions as to Diagnosis and Treatment, Baltimore, 1940, Williams & Wilkins Company, 232 pp.
105. Evans, J. P.: The Physiologic Basis of the Neurogenic Bladder, *J. A. M. A.* 117: 1927-1930, 1941.
106. McLellan, F. C.: The Neurogenic Bladder, Springfield, Ill., 1939, Charles C Thomas, Publisher, 206 pp.
107. Bauer, G.: Report at Meeting of Northern Surgical Society, Oslo, June 29-July 1, 1939, reviewed by James Hindmarsh, *SURGERY* 9: 151, 1941.
108. Edwards, W. B., and Hingson, R. A.: Continuous Caudal Anesthesia in Obstetrics, *Am. J. Surg.* 57: 459-464, 1942.
109. Cleland, J. G. P.: Paravertebral Anesthesia in Obstetrics, *Surg., Gynec. & Obst.* 57: 51-62, 1933.
110. Curtis, A. H., Anson, B. J., Ashley, F. L., and Jones, T.: The Anatomy of the Pelvic Autonomic Nerves in Relation to Gynecology, *Surg., Gynec. & Obst.* 75: 743-750, 1942.

# Book Reviews

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**Medical Progress Annual.** Vol. III. By Robert N. Nye, M.D. Pp. 678, with no illustrations. Springfield, Ill., 1942, Charles C Thomas, Publisher. \$5.

This monograph consists of a series of papers on subjects of general interest written by a number of well-known New England contributors, largely from Boston, in the field of their special interests. In the main, papers are written on such general topics as bacteriology, nutrition, pathology, pharmacology, and physiology. There are, however, a large number of specific items involving problems of practical clinical therapeutic interest. In a sense, the book professes to collect the important recent developments and outline the trend of thought in special fields. This objective is achieved particularly well in a number of the essays. In essence, the monograph affects to present the subject matter of year books in many special fields in briefer form. A large number of the essayists are well-known men in American medicine, who write knowingly and critically of recent contributions in their special fields. The volume constitutes an important addition to the review literature of developments in medicine.

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**Textbook of Exodontia.** By Leo Winter. Ed. 5. Pp. 576, with 485 illustrations and 7 color plates. St. Louis, 1943, The C. V. Mosby Company. \$10.00.

In this book the subjects of exodontia, local and general anesthesia, and oral surgery are covered in a very thorough manner. The text is designed to provide the student and the general practitioner of dentistry with the fundamental facts of exodontia, and as thorough and detailed a description of the techniques as possible.

The author realizes that the present emergency requires that the general practitioner should be thoroughly familiar with anesthesia and, therefore, has completely revised and brought up to date the chapter on local anesthesia.

The psychologic approach to exodontia patients is discussed, as well as the technique for extraoral injections, the techniques for infiltration and intraoral nerve block, accidents and infections following local anesthesia, general anesthesia in oral surgery, general anesthesia for ambulatory dental patients, chemotherapy, surgical preparation of the mouth for dentures, description and removal of impactions, and cysts of the jaw.

This very comprehensive text should be of great help to the general practitioner of dentistry, especially now that most of the specialists in exodontia and oral surgery are in the Service. The book is highly recommended.

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**Textbook of Gynecology.** By Arthur Hale Curtis, M.D., Professor and Chairman, Department of Obstetrics and Gynecology, Northwestern University, Evanston, Ill. Ed. 4. Pp. 723, with 401 illustrations. Philadelphia, 1942, W. B. Saunders Company.

This book is now in its fourth edition and has come to occupy an enviable place as a well-balanced practical text on gynecology. In this edition, the anatomic studies of the perineum, discussed recently by the author in conjunction with Anson

and Ashley, are reproduced in the graphic manner of their artist-author, Tom Jones. These illustrations, together with the anatomic features of the various surgical procedures, constitute a contribution to the volume. In many of these drawings, the blood vessels and tissue are shown in color. The illustrations throughout the volume are of a high order, and bespeak the importance which the author attaches to augmenting the written word by the enlightening influence of suitable pictures. The text contains 56 chapter headings—all within the confines of 723 pages, including therein, 401 illustrations. The volume can be recommended enthusiastically as a useful and practical text in which the greater emphasis is placed on operative gynecology.

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**The Hemorrhagic Diseases and the Physiology of Hemostasis.** By Armand J. Quick, Ph.D., M.D., Associate Professor of Pharmacology, Marquette University School of Medicine, Milwaukee, Wis. Ed. 1. Pp. 310, with 24 illustrations. Springfield, Ill., 1942. Charles C Thomas, Publisher. \$5.

This is an up-to-date summary of our knowledge of hemorrhagic diseases, written by an active and successful worker in a difficult field. The monograph contains an interesting historical account of development of knowledge covering the clotting of blood. The items considered important in the mechanism of blood coagulation are discussed in detail. The avitaminosis K deficiency and the related hemorrhagic diathesis, a field to which the author has added important contributions, are discussed at length and particularly well. The inclusion of an appendix on methods makes the monograph an especially well-balanced and practical book. An extensive list of bibliographic references is appended to each chapter. The book can be recommended enthusiastically as a comprehensive and authoritative summary of our knowledge in the field of hemorrhagic diseases.

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**Roentgenographic Technique: A Manual for Physicians, Students and Technicians.** By Darmon Artelle Rhinehart, A.M., M.D., F.A.C.R., Professor of Roentgenology and Applied Anatomy, School of Medicine, University of Arkansas, Little Rock, Ark. Ed. 3, thoroughly revised. Cloth. Pp. 471, with 201 engravings. Philadelphia, 1943, Lea & Febiger.

The third edition of this standard text on roentgenographic technique is welcome. Some increase in the size of the book and some revisions of the text have been made. There are a number of new figures, some of which are very instructive. It is surprising that the author has chosen to omit such newer procedures as roentgen kymography and body section roentgenography, both of which have an important, though select place, in the methodology of x-ray examination. Otherwise the book is complete. It is well written, bountifully illustrated, and offers a valuable manual for the instruction of technicians and physicians who are concerned with the technique of x-ray examination.

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**Neurosurgery and Thoracic Surgery.** Prepared and edited by the Subcommittees on Neurosurgery and Thoracic Surgery of the Committee on Surgery of the Division of Medical Sciences of the National Research Council. Pp. 310, with 183 illustrations. Philadelphia, 1943, W. B. Saunders Company. \$2.50.

The purpose of this, the sixth of a series of military surgical manuals, is to provide to military medical officers succinct and peremptory information on the management of injuries to the central and peripheral nervous systems as well as on the treatment of thoracic wounds. The volume has been judiciously planned

and comprehensively presented by a group of highly qualified and thoroughly experienced neurosurgical and thoracic specialists. Ample illustrations enhance and elucidate the discussion.

Approximately two-thirds of the book is devoted to neurosurgical subjects. In the first chapter on gunshot and other injuries of the scalp, skull, and brain, prepared by Gilbert Horrax and Claude C. Coleman, specific directions are given for the management of head injuries sustained on the battlefield. Claude C. Coleman and Cobb Pilcher discuss gunshot and other injuries of the spinal cord in the second chapter. The third chapter, by J. Grafton Love, is devoted to the diagnosis and treatment of intervertebral discs in military service, which is equally applicable to civilian practice. A detailed description of the peripheral nerves and a complete discussion of the method of examination of peripheral nerve injuries are presented by Byron Stookey and John Scharff in the fourth chapter. The subject of infections of the nervous system and its coverings arising from injuries sustained in the service is completely covered in the fifth chapter by Charles Bagley, Jr., Francis C. Grant, and Gilbert Horrax.

The last third of this monograph contains a complete though laconic and synoptic discussion of the subject of trauma to the chest prepared by Evarts A. Graham, Isaac A. Bigger, Edward D. Churchill, and Leo Eloesser. First-aid measures, classification, complications, and surgical techniques of thoracic injuries are covered in detail.

Not only has the purpose of the book been commendably achieved, but this manual will find a useful place on the shelf of the civilian surgeon who has been compelled by the exigencies of war to take care of a greater variety of patients.



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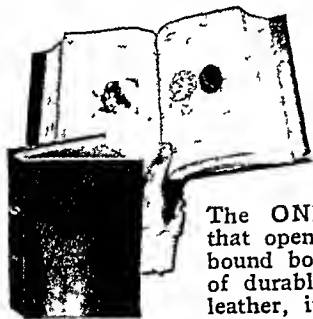
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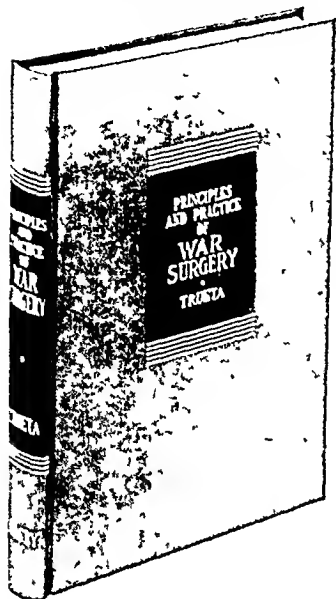
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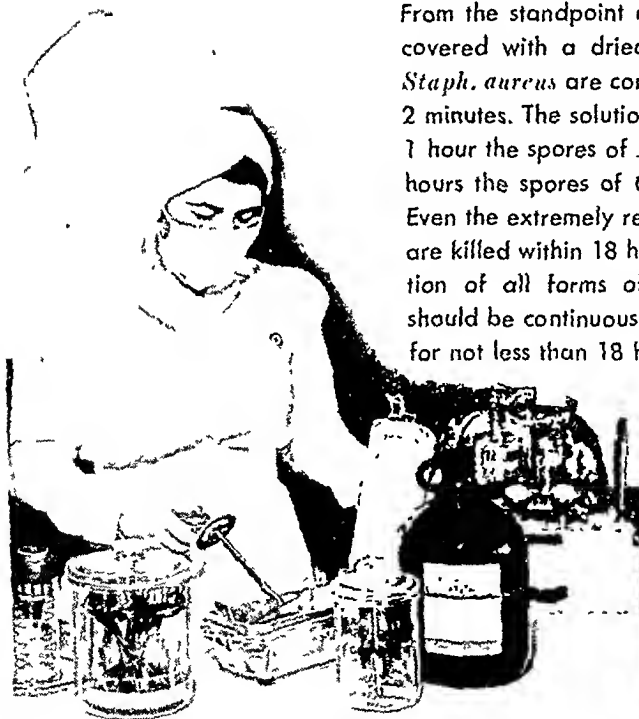
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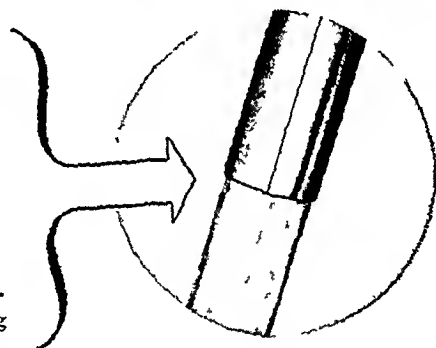
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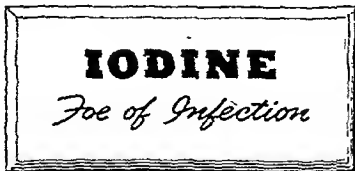


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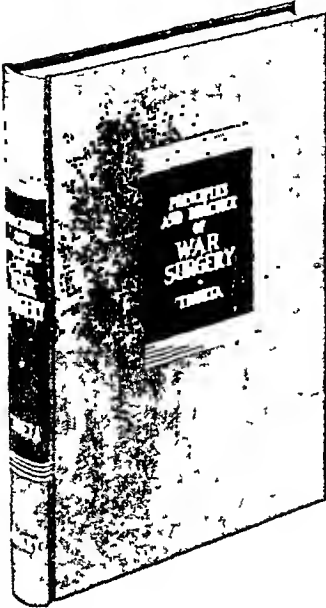
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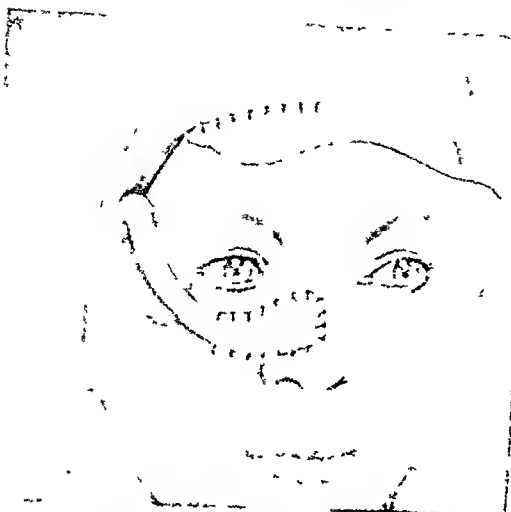
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(Catgut) Tubing Fluid as a Tissue Irritant. Ann. Surg., 118: 269, Aug., 1943. Jenkins, H. P., and Dunham, C. L.: Irritant Properties of Tubing Fluids as a Factor in the Tissue Reactions Observed with Surgical Gut (Catgut). Ann. Surg., 118: 288, Aug., 1943.

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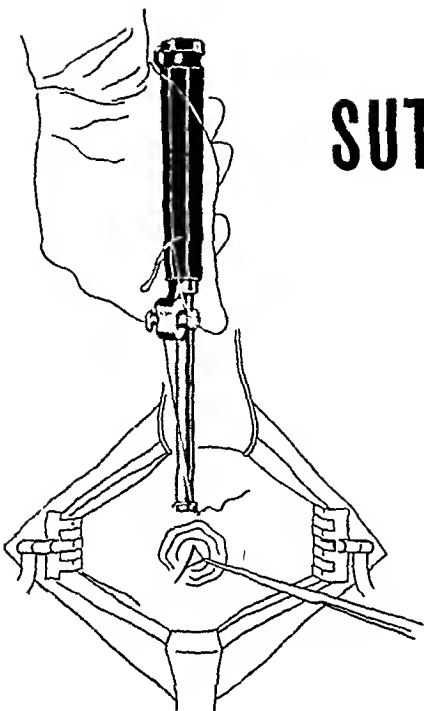
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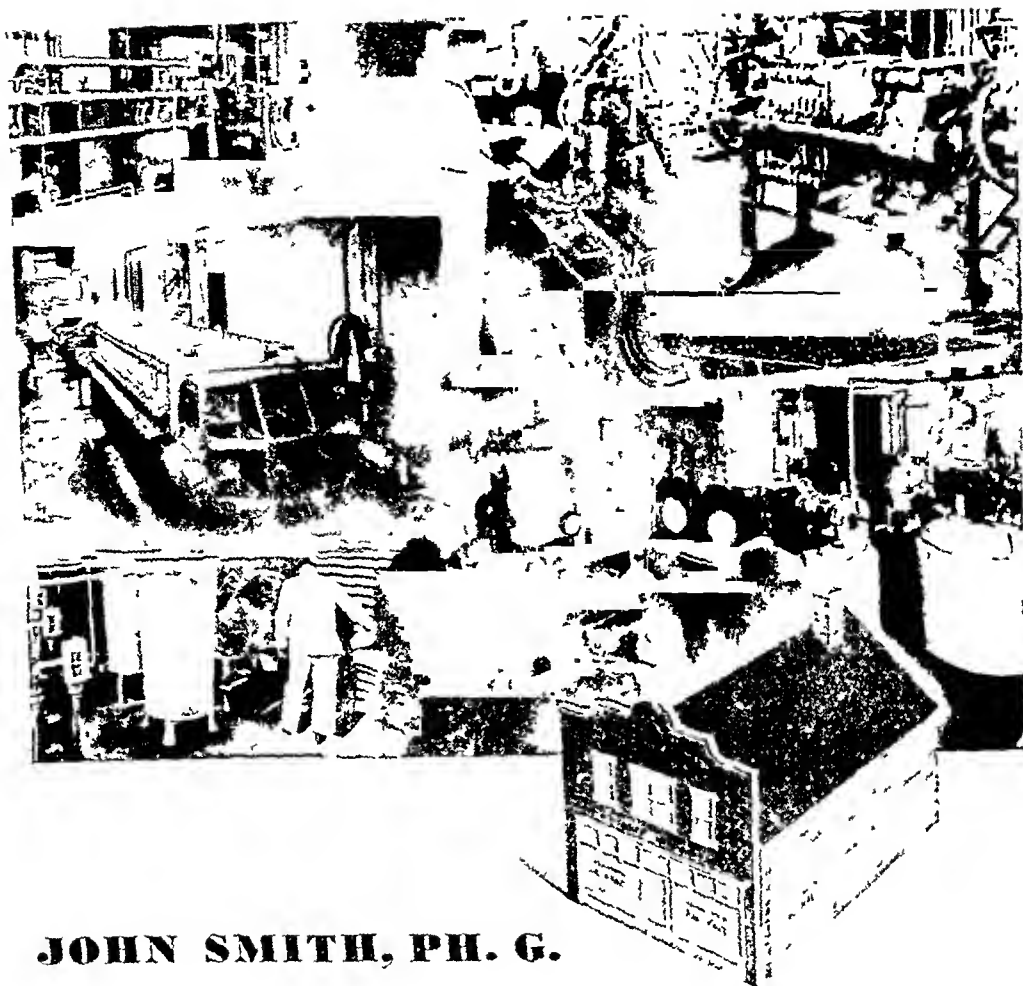
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# SURGERY

Vol. 15

APRIL, 1944

No. 4

## Original Communications

### THE USE OF PLASMA FOR FILLING THE PLEURAL SPACE AFTER LOSS OF VARYING AMOUNTS OF LUNG

W. E. ADAMS, M.D., AND T. F. THORNTON, M.D., CHICAGO, ILL.

*(From the Department of Surgery of the University of Chicago)*

THE surgical treatment of diseases of the thorax has made rapid progress within the past two decades and at the present time operations made through an open pleural cavity are commonplace. Resections of one lobe or of an entire lung for inflammatory conditions and for malignancy are made in increasing numbers. Several factors have contributed materially in the reduction of the mortality of these operations, namely, improvements in diagnostic methods, prevention of shock and severe sepsis, and an understanding of how to maintain the normal function of the organs of the thorax during a surgical pneumothorax.

In spite of the progress made in this field of surgery the present morbidity and mortality rates indicate that further improvement is possible. Better results should be obtained when the various body functions are maintained as nearly normal as possible. In the resection of varying amounts of lung tissue (as with other intrathoracic operations) alteration of the blood may be considerable due to the loss of blood and plasma. Several factors not commonly encountered in operations on other organs may contribute to this alteration, namely, (1) the incision is long and usually divides heavy bellied muscles transversely, (2) vascular adhesions are frequently encountered, and (3) the amount of blood within the lung may be considerable. Following these operations, due to the trauma dealt the chest wall, pleura, etc., both cells and plasma of the circulating blood are lost, part of this being drained away (as much as 600 to 1,200 c.c. following lobectomy) or allowed to accumulate in the pleural space (as in pneumonectomy).

The work described in this communication was done under a contract, recommended by the Committee on Medical Research, between the Office on Scientific Research and Development and the University of Chicago.

Received for publication, Oct. 25, 1943.

An analysis of this fluid reveals a slightly lower total protein value than is present in normal blood. Unless replacement therapy is instituted this may lead to a considerable reduction in blood plasma protein, as much as 33½ per cent, or to a level as low as 4.0 to 4.5 Gm. per cent. Just how much this might influence the convalescence of the patient would probably vary with the degree of toxicity, the status of the cardio-renal function, etc. (Cardiac failure and cardiorenal failure have been diagnosed as the cause of sudden postoperative exodus when no other cause could be found on post-mortem examination.) It therefore would seem quite logical that the postoperative course of a patient would be less complicated when a more nearly normal blood picture was maintained.

Since resection of the lung is at present frequently indicated (for malignancy, bronchiectasis, lung abscess, and tuberculosis), the factor of blood protein replacement assumes greater importance. In order to determine the method of choice for replacement of protein loss the following plan for experimentation was outlined:

A. Determination of the blood plasma protein fall

1. Due to anesthesia.
2. Due to exploratory thoracotomy.
3. Due to resection of lung tissue with and without the complication of infection.

B. Determination of the replacement therapy needed and the optimum route of administration to prevent the above fall in blood plasma proteins by giving:

1. Blood transfusions.
2. Serum transfusions.
3. Serum intrapleurally.
4. Serum intrapleurally and blood transfusions.

EXPERIMENTAL METHODS AND PROCEDURES

*Animals.*—In an attempt to produce hypoproteinemia as seen clinically following lung resections, several different species of animals were tested, namely, rats, cats, rabbits, goats, and dogs. In order to produce a pleural effusion similar to that seen clinically following intrathoracic operations, a number of procedures were employed, such as mechanical and chemical irritation of the pleura, and the leaving of a foreign body (sponge) in the pleural space following a lung resection. Dogs and goats proved to be more adaptable to the problem, and since goats were not readily obtainable in large numbers and were much less economic, most of the experiments were made on dogs. Although an attempt was made to use only healthy animals, pulmonary infection was quite prevalent during the spring and autumn seasons. The presence of infection proved to be of definite value since it offered an opportunity of studying the influence of this factor in the problem under investigation.

*Procedure.*—Preoperative weight, temperature, and blood studies were routine, the latter including red cells, hemoglobin, hematocrit and total protein determinations. Since the protein loss involved chiefly the albumin factor, after the earlier experiments only a total plasma protein determination was made. In the first few experiments both the Kjeldahl<sup>1</sup> and densimeter falling drop<sup>2</sup> methods for determining plasma proteins were employed. When properly performed these methods checked quite accurately, thus the gravity method was used thereafter. (The values with this method are slightly lower than those obtained by the Kjeldahl because they do not include the nonprotein nitrogen.)

*Operation.*—After trying several variations of technique, two operative procedures were used, namely, (1) lobectomy using mattress suture technique and (2) pneumonectomy, using the dissection and individual ligation technique in one group and the mattress suture technique in another group. These procedures were similar to those used clinically and produced the desired results. The operative approach was the same for all animals, that is, through the left fifth interspace without rib resection. The muscles were divided in the direction of their fibers thus minimizing the amount of trauma and plasma protein loss in the chest wall wound. Ether anesthesia delivered through an intratracheal catheter under mild positive pressure was routinely employed and was preceded by morphine, 0.015 Gm. subcutaneously. Silk suture material was used throughout. The pleura was massaged with a sponge (2 by 2 inches) which was left in the pleural cavity when the chest wall was closed (see Figs. 1, 2, and 3).

*Postoperative Course and Studies.*—Following operation the preoperative studies were repeated daily (temperature and plasma proteins) or two to three times a week (hemoglobin, red cells, and hematocrit) for the first two weeks and somewhat less often thereafter. In addition to these studies, thoracenteses and cultures of the pleural fluid were made biweekly along with fluoroscopic and x-ray examinations when necessary (one to three times a week) (see Fig. 4).

The control series of animals included a group of six dogs receiving ether anesthesia (1.25 to 1.5 hours) only, and a second group of eleven dogs having a thoracotomy made, but without lung resection. In other groups a lobectomy was made in seven dogs and a pneumonectomy in sixteen dogs.

The animals receiving replacement therapy were divided into four groups according to the method of management.

In Groups A and B blood or plasma transfusions were given the day of operation and repeated on the first and sometimes the third day following operation. In Group C serum was given intrapleurally at the end of a total pneumonectomy. Group D received the combined treatment of Groups A, B, and C, namely, blood intravenously and serum intrapleurally.

## RESULTS OF EXPERIMENTS

*A. Control series.*—In order to evaluate the various factors contributing to the lowering of blood plasma proteins following lung resection, the control experiments were divided into four main groups: (1) anesthesia, 6 dogs; (2) thoracotomy, 11 dogs; (3) lobectomy, 7 dogs; and (4) pneumonectomy, 16 dogs.

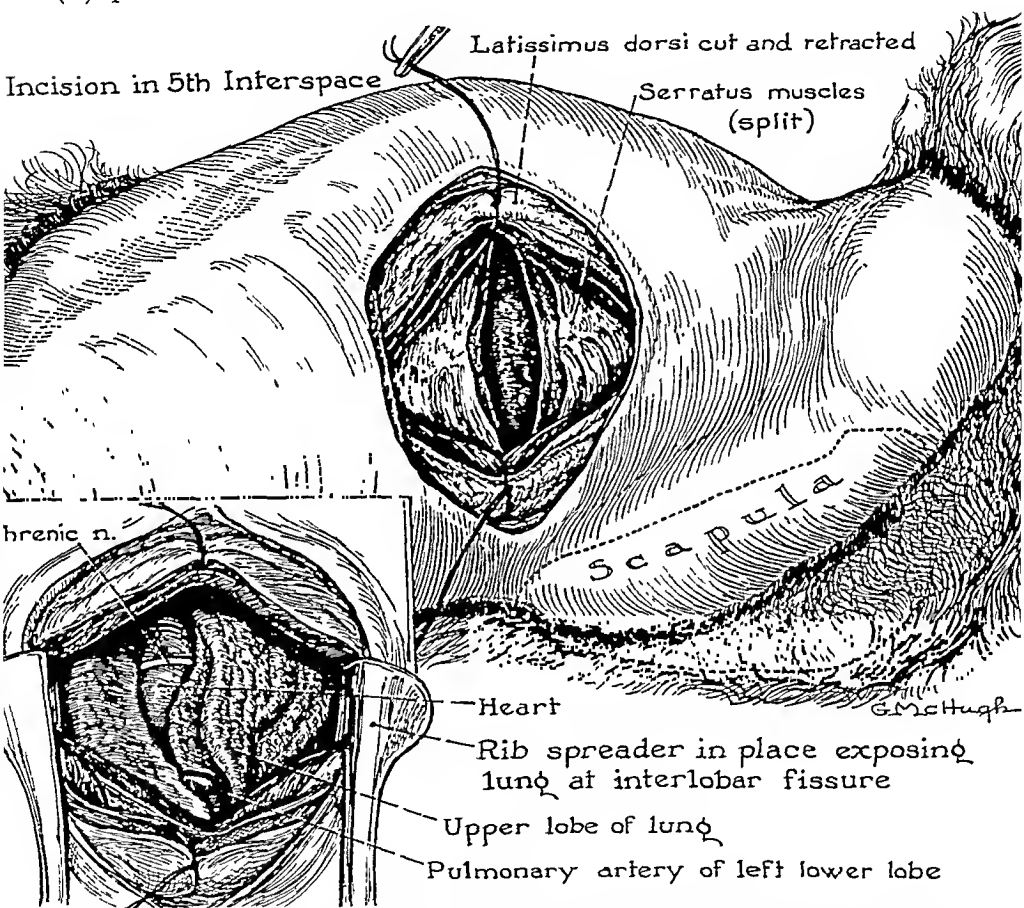


Fig. 1.—Drawing of operative approach for total pneumonectomy through the left fifth interspace. The latissimus dorsi and serratus muscles are divided in the direction of their fibers.

*Anesthesia.*—Ether anesthesia administered for 1.25 to 1.5 hours produced an average fall in blood plasma proteins of 0.48 Gm. per cent for the six dogs. This usually occurred within the first three days following the anesthesia. There were no fatalities (see Table II).

*Thoracotomy.*—Thoracotomy wounds without lung resection were made in eleven dogs, a sponge being left in the pleural cavity. In five of these the incision was small as for draining an empyema. The average fall in blood plasma proteins for this group was 0.45 Gm. per cent (0.35, 0.74, 0.66, 0.10, and 0.43 Gm. per cent). In six other dogs the incision

gave wide exposure such as needed for lung resection. The average fall in this group was 0.85 Gm. per cent (0.93, 0.91, 0.91, 0.70, 0.87, and 0.80 Gm. per cent). The lowest blood plasma protein reading usually occurred on the second to the fourth postoperative day. A late chest wall infection caused the only death in the group of 11 dogs (see Table II).

TABLE I  
SUMMARY OF PLASMA PROTEIN STUDIES FOLLOWING LOBECTOMY AND PNEUMONECTOMY IN DOGS

		NO. DOGS	INFECTED	INFECTED GROUP PLASMA PROTEIN FALL		NONINFECTED GROUP PLASMA PROTEIN FALL	
				AVERAGE	RANGE	AVERAGE	RANGE
<i>A. Reduction of plasma proteins in lobectomy and pneumonectomy</i>							
1. Ether anesthesia	alone	6	0	—	—	0.48	0 0.97
2. Exploratory thoracotomy	small	5	0	—	—	0.45	0.10 0.74
	large	6	2	0.93 0.91		0.82	0.70 0.92
3. Lobectomy mattress suture		7	5	1.50	1.01 2.47	0.28 0.38	
4. Pneumonectomy— mattress suture		10	5	1.20	0.28 1.88	1.34	0.42 1.99
individual ligation		6	2	1.36 2.05		1.30	0.80 1.60
<i>B. Replacement of plasma protein loss in lobectomy and pneumonectomy</i>							
1. Lobectomy (mattress suture)							
(a) Serum transfusion		8	5	0.58	0 1.40	0.28	0 0.74
(b) Blood transfusion		4	3	0.63	0 1.33	0.28	
2. Pneumonectomy (mattress suture)							
(a) Serum transfusion		5	3	1.05	0.74 1.50	0.43	
(b) Blood transfusion		2	1	1.29		0.84	
3. Pneumonectomy (individual ligation)							
(a) Serum transfusion		6	1	0.77		0.56	0.15 1.53
(b) Serum intrapleurally							
200 c.c.		11	3	1.0	0.74 1.22	0.79	0.24 1.29
400 c.c.		13	7	0.62	0 1.26	0.52	0 1.58
(c) Blood transfusion		8	3	0.34	0 0.53	0.44	0 1.11
(100 c.c.) and serum							
intrapleurally (200							
c.c.)							

*Lobectomy.*—The operation of lobectomy was made, using two different techniques, but it was soon found that the mattress-suture technique was the only one applicable for the experiment. In seven dogs, the left

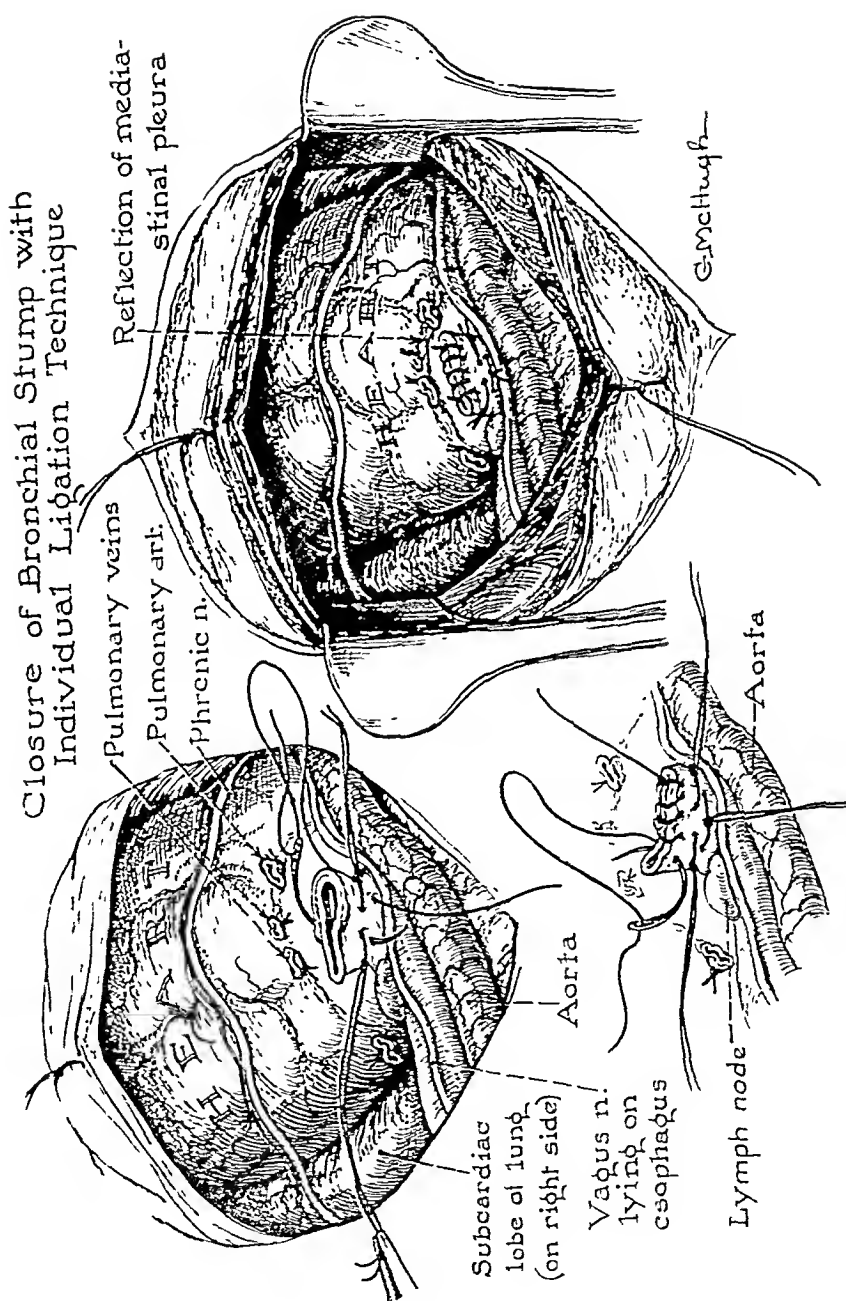


Fig. 2.—Drawing showing closure of the left primary bronchus with two rows of sutures in pneumonectomy by individual ligation technique.

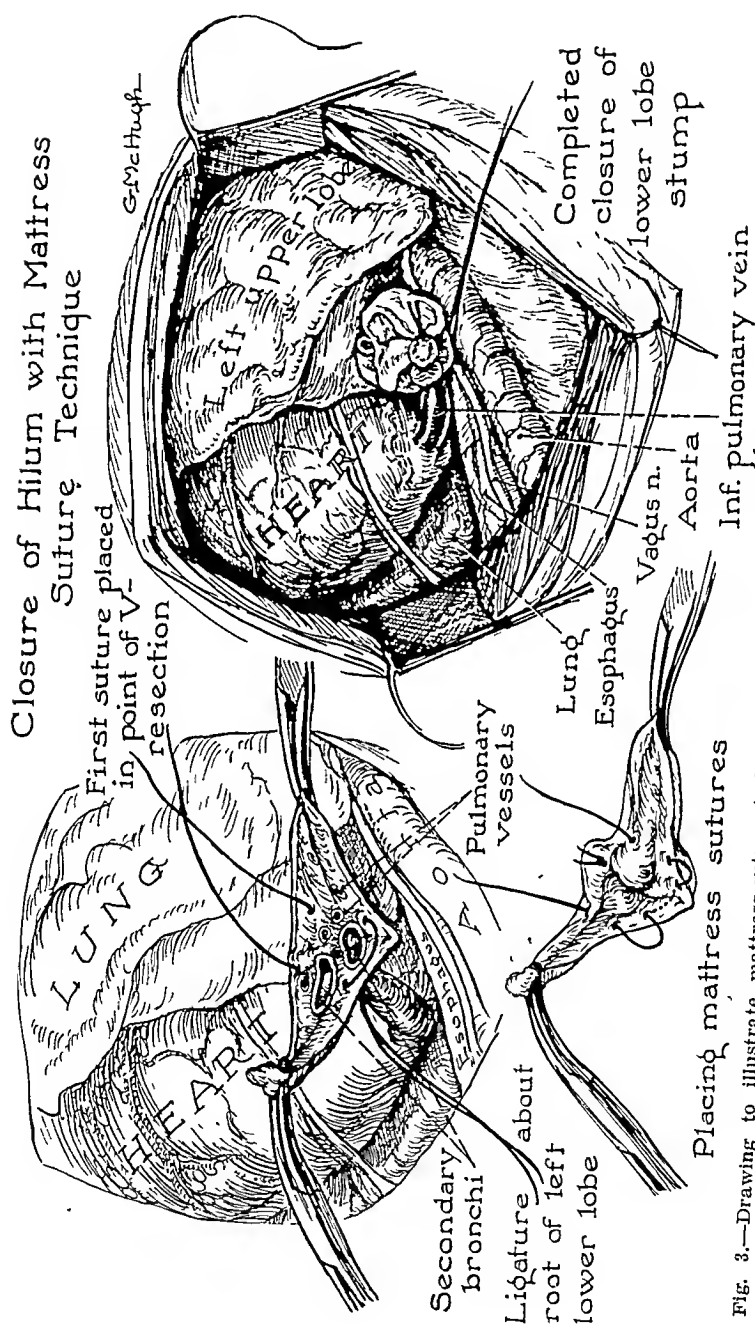
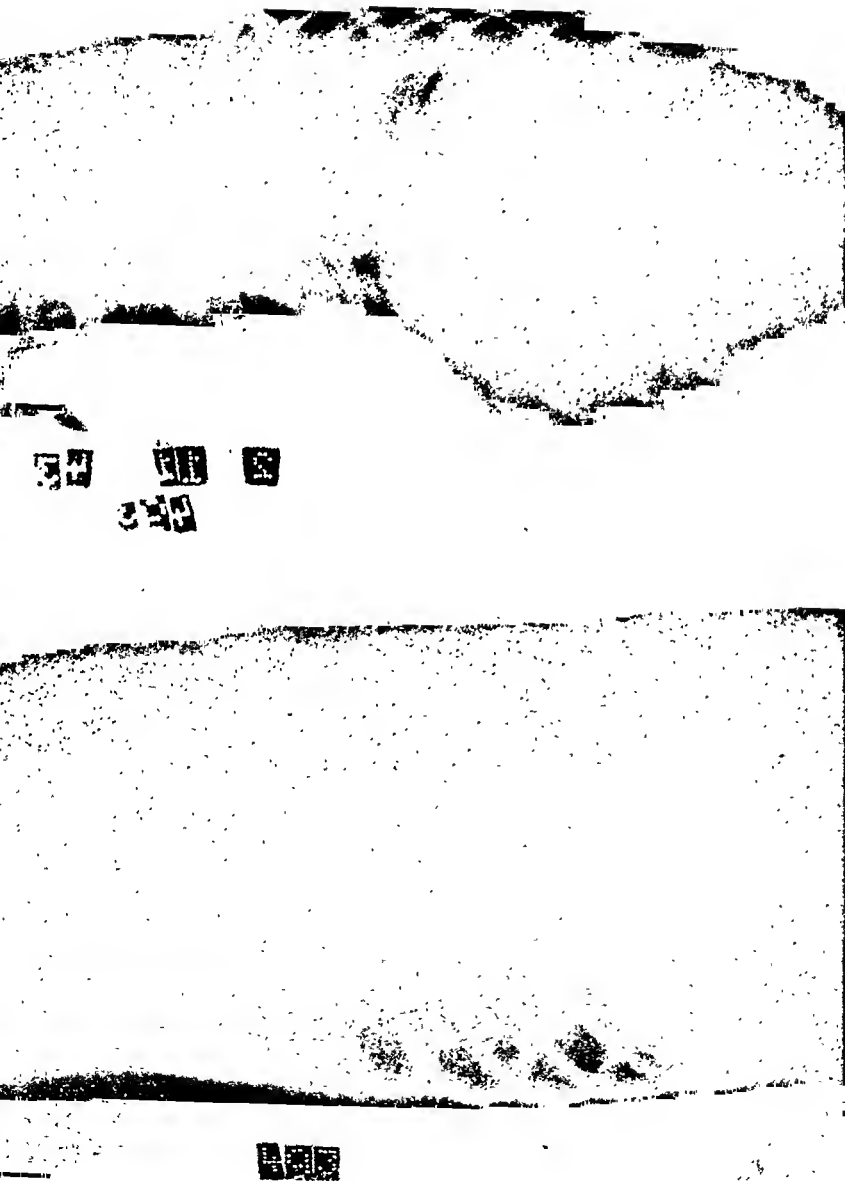


Fig. 3.—Drawing to illustrate mattress-suture technique of closing the bronchi and vessels in left lower lobectomy.



A.

B.

Fig. 4 A, B, and C.—X-rays of the chest of Dog 493 taken one day, seventeen days, and forty-two days respectively following total pneumonectomy (left) by the individual ligation (dissection) technique.

Note opacity of left pleural space on first day following operation (200 c.c. of serum were placed in this space at the conclusion of the operation). The subcardiac lobe was more evident in the second X-ray and the opaque area was markedly diminished in size. The third X-ray revealed further diminution of left pleural opacity with deviation of the heart toward the left thoracic wall and further expansion of the subcardiac (accessory) lung lobe. On sacrificing the animal the following day, only 5 c.c. of clear serum remained in the left pleural space. There was no pneumothorax.



lower lobe was removed, five of which were infected. The infection was usually on the basis of distemper or empyema following operation. The average fall in blood plasma protein for this group was 1.5 Gm. per cent, the range of fall varying from 1.01 to 2.47 Gm. per cent. The lowest plasma protein level for the group was 3.96 Gm. per cent and was observed on the second day following operation. (See Table III, Dog 270.)

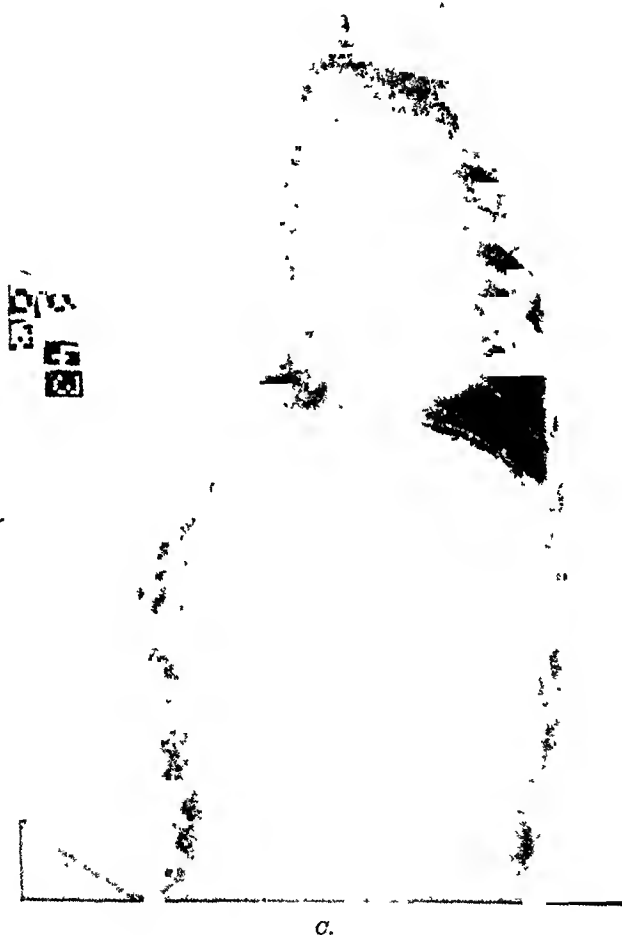


Fig. 4C.—(For legend see opposite page)

*Pneumonectomy.*—The operation of pneumonectomy was performed using two different techniques for closing the bronchial stump, namely, mattress suture, and individual ligation techniques. In the first group of ten dogs where the bronchial stumps were closed by multiple mattress sutures, five were complicated by an infection due to distemper or empyema. The average fall in blood plasma proteins for this group was 1.34 Gm. per cent of the noninfected, and 1.20 for the infected group. The lowest plasma protein level was 3.96 Gm. per cent (see Table III,

TABLE II  
REDUCTION OF TOTAL PLASMA PROTEINS BY ANESTHESIA AND THORACOTOMY

REDUCTION OF TOTAL PLASMA PROTEIN

DOG NO.	INITIAL WEIGHT (KG.)	INITIAL HEMATOLOGIC FINDINGS			INFECTION PRESENT	PLEURAL FLUID REMOVED (C.C.)	LOWEST TOTAL SERUM PROTEIN (GM. %)	TIME FOLLOWING PROCEDURE (DAYS)	AMOUNT OF FALL IN P.P. (GM. %)	HEMATOLOGIC FINDINGS AT TIME OF LOWEST PLASMA PROTEIN LEVEL			DIED OR SACRIFICED	REMARKS
		HEMA-TOCRIT	HIB.	R.B.C.						HEMA-TOCRIT	HIB.	R.B.C.		
Ether anesthesia for 1.25 hours in 6 dogs														
349	17.7	5.14	40	14.5	5.6	—	5.35	1	0	14.0	6.4	5		
350	16.3	5.39	41	14.5	7.0	—	5.28	1	0.11	14.5	6.6	5		
316	6.8	5.25	58	14.	8.9	—	4.73	1	0.52	12.5	7.8	5		
338	9.0	6.85	43	—	7.8	—	5.88	1	0.97	—	8.0	5		
384	8.5	6.30	46	—	8.6	—	5.60	3	0.70	—	7.0	5		
385	17.2	6.33	62	16	9.0	—	5.74	3	0.59	15.0	7.8	5		
Average fall in plasma proteins—0.48 Gm. %														
Exploratory thoracotomy—small incision in 5 dogs														
379	8.2	5.35	—	—	—	0	5.60	1	0.35	—	—	5		Sponge left in chest; temperature elevation of 1 to 2° F.
382	7.5	5.64	—	—	—	300	4.90	2	0.74	—	—	5		
383	7.8	5.46	—	—	—	400	4.80	3	0.66	—	—	5		
385	17.6	5.80	—	—	—	200	5.70	2	0.10	—	—	5		
388	13.1	5.60	—	—	—	0	5.18	3	0.42	—	—	5		
Average fall in plasma proteins—0.45 Gm. %														
Exploratory thoracotomy—large incision in 6 dogs														
378	13.9	5.31	43	12.5	7.6	+	4.38	4	0.93	10.0	7.0	D		No sponge left in chest,
379	6.9	5.88	47	10.5	7.8	+	4.97	4	0.91	11.0	8.0	S		chest clear on fluoros-
382	7.8	5.39	48	10.5	7.6	—	4.48	3	0.91	10.5	8.0	S		copy; temperature ele-
383	8.25	5.74	46	12.0	7.6	—	5.04	2	0.70	10.0	7.2	S		vation of 1 to 2° F.
388	12.7	6.01	45	16.0	7.2	—	5.14	4	0.87	15.0	6.7	S		
389	8.5	5.56	42	15.5	6.2	—	4.76	3	0.80	15.0	6.4	S		
Average fall in plasma proteins—0.85 Gm. %														

Dog 430). In the second group of six dogs, where the stump was closed by individual ligation technique, only two dogs were infected, one due to distemper, the other due to an open bronchus. The average fall in blood plasma protein for this group was 1.31 Gm. per cent for the non-infected and 1.70 Gm. per cent for the infected. The greatest fall usually appeared between the second and fourth days following operation. The range of fall in plasma proteins was from 0.8 to 2.05 Gm. per cent. The lowest plasma protein level observed was 4.24 Gm. per cent (see Table III, Dog 389). A large percentage of the animals in the control series showed a fall in plasma proteins to a level between 4.0 and 4.75 Gm. per cent.

Thus, in summarizing the results of the control series, it is seen that the lowering of blood plasma protein following the resection of lung tissue is in part due to (1) the anesthesia, (2) the operation on the chest wall, (3) removal of lung tissue per se, and (4) infection when present, the amount of fall being almost the same following pneumonectomy as following lobectomy.

**B. Replacement.**—These experiments fell into three main groups: namely: (1) lobectomy, (2) pneumonectomy with mattress suture technique, and (3) pneumonectomy with individual ligation technique.

**Lobectomy.**—Twelve animals were included in this group of lobectomies, eight of which received serum intravenously, and four received whole blood transfusions as their replacement therapy. This was usually administered in 200 c.c. amounts of serum, and approximately 165 c.c. of whole blood intravenously at any one time. The replacement material was usually given on the day of operation and on the second and third days following operation. Of the eight animals receiving serum, five were infected, three due to distemper, one due to chest wall infection, and the fifth to empyema. The average fall in blood plasma proteins for these five animals was 0.58 Gm. per cent, the range being from 0 to 1.40 Gm. per cent. The three noninfected dogs averaged a fall of 0.28 Gm. per cent with a range of 0 to 0.70 Gm. per cent.

Of the four animals receiving whole blood, three were infected, two due to bronchial stump leak and one to distemper. The average fall in blood plasma protein for these three animals was 0.63 Gm. per cent, the range being from 0 to 1.33. The noninfected animal had a fall of only 0.28 Gm. per cent.

**Pneumonectomy—Mattress-suture Technique.**—In this group of seven dogs, in which mattress-suture technique was used, five received plasma intravenously, and two, whole blood intravenously. Of the first five, three were infected, two of which were due to distemper, and one due to empyema. The average fall for the three infected was 1.05 Gm. per cent. The fall for the two non-infected was 1.2 Gm. per cent. Of the two receiving whole blood intravenously, one was infected (empyema). The blood plasma protein fall in this case was 1.29 Gm. per cent. The noninfected animal had a fall of 0.84 Gm. per cent.

TABLE III  
REDUCTION IN TOTAL PLASMA PROTEINS BY LOBECTOMY AND PNEUMONECTOMY

DOG NO.	INITIAL WEIGHT (KG.)	INITIAL HEMATOLOGIC FINDINGS				INFECTIOUS PRESENT	PLEURAL FLUID REMOVED (C.C.)	LOWEST TOTAL SERUM PROTEIN (GM. %)	TIME FOLLOWING PROCEDURE (NO. DAYS)	AMOUNT OF FALLOUT (GM. %)	HEMATOLOGIC FINDINGS AT TIME OF LOWEST PLASMA PROTEIN LEVEL				REMARKS
		INITIAL TOTAL SERUM PROTEIN		INITIAL HEMATOLOGIC FINDINGS							HEMATOLOGIC FINDINGS AT TIME OF LOWEST PLASMA PROTEIN LEVEL				
		H.E.M.A.-TOCRIT	H.B.	R.B.C. M.	H.E.M.A.-TOCRIT						H.B.	R.B.C. M.	DIED OR SACRIFICED		
Left lower lobectomy (mattress suture) in 7 dogs															
346	10.5	5.74	49	16.5	7.3	-	0	5.46	7	0.28	43	15.0	7.3	S	
262	11.7	5.46	53	15.5	7.5	-	120	5.14	4	0.32	48	17.0	6.5	S	
338	10.5	5.60	36	13.5	5.1	+	110	4.31	3	1.29	36	14.5	6.1	S	Small empyema healed
347	11.6	5.70	51	17.0	7.2	+	212	4.69	3	1.01	49	15.0	8.3	D	Empyema
221	12.0	6.05	-	-	-	+	400	4.52	3	1.53	46	13.4	5.8	D	Empyema
315	18.5	6.85	-	-	-	+	500	4.38	3	2.47	45	13.5	5.9	S	Empyema, healed by aspiration
270	13.0	5.18	47	16.0	5.8	+	410	3.96	2	1.22	40	13.5	5.5	S	Wound infection
Average fall—1.16 for 7 dogs															
Left total pneumonectomy (mattress suture) in 10 dogs															
323	20.0	6.16	46	16.0	5.8	+	855	4.76	3	1.40	38	15.5	5.1	D	Empyema
324	14.2	5.98	46	16.5	7.5	+	790	4.10	6	1.88	31	12.0	5.4	D	Distemper, chest wall infection
329	11.3	6.22	40	16.0	7.6	+	150	4.86	2	1.26	38	15.5	5.6	D	Distemper
330	9.2	5.35	34	13.5	5.1	+	285	5.07	2	0.28	38	14.5	5.4	D	Distemper empyema
429	7.7	6.12	51	15.0	7.1	+	400	4.94	1	1.18	-	-	-	D	Distemper empyema
208	14.7	6.12	45	14.5	8.5	-	60	5.70	3	0.42	48	16.0	7.8	S	

[illegible]



The seven animals having pneumonectomy received only one-half as much replacement therapy as the preceding lobectomy group, thus explaining the greater fall in blood protein. In spite of this, a plasma protein level of approximately 5.0 Gm. per cent or above was maintained in all of the dogs (except the two receiving whole blood replacement).

*Pneumonectomy—Individual Ligation Technique.*—This group of thirty-eight animals in which individual ligation technique was used was divided into three parts.

1. Part one included six animals which received 400 c.e. of serum intravenously in two injections. Only one of this group was infected, this being due to an open bronchus. Of the five noninfected dogs, the average fall in plasma proteins was 0.56 Gm. per cent, the range being from 0.15 to 1.53. The one infected animal had a fall of 0.77 Gm. per cent. The lowest level for this group was 4.83 Gm. per cent.

2. In part two, twenty-four animals were subdivided into two groups.

Group A. Eleven dogs received 200 c.e. of serum intrapleurally at the time of operation. Three of these were infected; one had distemper and the other two developed an empyema. Of the three infected, the average fall was 1.0 Gm. per cent. For the remaining eight noninfected dogs, the average fall was 0.79 Gm. per cent, the range being from 0.24 to 1.29.

In Group B each of thirteen dogs received 400 c.e. of serum intrapleurally at the time of operation. Seven of these thirteen were infected; five had distemper and two developed an empyema. The average fall for the infected group was 0.62 Gm. per cent, the range being from 0 to 1.26. For the non-infected group of six dogs, the average fall was 0.52 Gm. per cent, with a range from 0 to 1.58 Gm. per cent. Only one of the thirteen animals receiving 400 c.e. of serum intrapleurally had a blood plasma protein level below 4.85 Gm. per cent and only four below 5.0 Gm. per cent.

3. In part three, eight animals each received 200 c.e. of serum intrapleurally at the time of operation and 100 c.e. of blood intravenously. Of the eight animals, three were infected; one had distemper, the other two developed an empyema. The average fall for these three was 0.34 Gm. per cent, with a range of 0 to 0.53. The average fall for the five noninfected was 0.44 Gm. per cent, with a range of 0 to 1.11. The reason for the infected group not falling more was probably that most of the animals had a very low plasma protein level before operation; namely, 4.06, 4.85, and 5.64.

In summarizing the results for the treated series, several facts were brought out: A marked fall in blood plasma proteins could usually be prevented by the intravenous administration of either serum or whole blood in sufficient amounts. A similar result could be obtained by the use of adequate amounts of serum intrapleurally. In infected animals a greater fall was observed than in the noninfected and could not be

TABLE V  
REPLACEMENT OF PLASMA PROTEIN LOSS IN PNEUMONECTOMY

REPLACEMENT OF PLASMA PROTEIN LOSS IN PNEUMONECTOMY

DOG NO.	INITIAL WEIGHT (KG.)	INITIAL TOTAL SERUM PROTEIN	INITIAL HEMATOLOGIC FINDINGS		REPLACEMENT THERAPY (G.C.)	INFECTION PRESENT	PLEURAL FLUID REMOVED (C.C.)	LOWEST TOTAL SERUM PROTEIN (GAL. %)	TIME FOLLOWING PROCEDURE (DAYS)	AMOUNT OF FALL IN P.P. (GAL. %)	HEMATOLOGIC FINDINGS AT TIME OF LOWEST PLASMA PROTEIN LEVEL		REMARKS			
			HEMA-TOCRIT	H.B.							R.B.C. M.	HEMA-TOCRIT		H.B.	R.B.C. M.	
A. Pneumonectomy using mattress suture technique in 7 dogs																
Left pneumonectomy with plasma transfusion in 5 dogs																
366	10.9	5.64	53	16.0	8.0	200	+	440	4.90	1	0.74	53	14.5	7.6	D	Died 2 days P.O. of distemper
372	19.4	5.98	58	15.0	7.6	300	+	285	4.90	4	1.08	58	16.0	8.6	D	Died 5 days P.O. of distemper
376	10.7	7.55	59	10.5	6.0	350	+	330	6.05	2	1.50	40	10.5	5.0	D	Died 5 days P.O. of empyema
305	21.5	7.30	67	16.5	9.8	300	-	305	4.97	2	2.33	47	15.0	7.2	S	
371	18.7	6.23	56	15.0	7.5	300	+	200	5.80	2	0.43	45	13.0	6.5	D	Died 2 days P.O. with bronchial leak and empyema
Left pneumonectomy with blood transfusion in 2 dogs																
350	15.9	5.53	45	16.0	7.0	300	+	535	4.24	5	1.29	71	18.0	8.0	D	Died 6 days P.O. of empyema
349	17.2	5.60	48	14.0	5.4	200	-	240	4.76	3	0.84	60	17.5	7.0	D	Tension pneumothorax, 4 days P.O.
B. Pneumonectomy using individual ligation technique in 38 dogs																
Left pneumonectomy with serum transfusion in 6 dogs																
413	6.5	5.31	57	14.0	6.6	400	-	320	4.83	2	0.48	50	13.0	6.1	S	
432	6.4	5.14	49	13.5	5.8	400	-	205	4.94	2	0.20	46	13.0	5.6	S	
336	7.7	5.50	57	14.0	6.4	400	-	690	5.35	6	0.15	50	12.0	5.7	S	
467	15.2	5.77	61	14.5	7.2	400	-	705	5.31	6	0.46	54	13.0	6.7	S	
472	10.1	6.36	60	15.0	6.2	400	-	625	4.83	3	1.53	-	-	-	S	
Average fall in plasma proteins for 5 dogs—0.56 Gm. %																
471	15.0	6.12	44	12.0	5.8	400	+	955	5.18	5	0.77	-	-	-	D	Died 6 days P.O. of tension pneumo- thorax and empyema
Average fall in plasma proteins for 6 dogs—0.60 Gm. %																
Left pneumonectomy with serum intrapleurally in 24 dogs																
493	10.0	5.70	69	17.0	7.1	200	-	T*	4.41	2	1.29	64	16.0	6.6	S	
220	14.4	6.36	60	16.0	6.4	200	-	T	5.60	1	0.76	56	15.5	6.2	S	
505	6.6	6.09	58	14.0	6.2	200	-	T	4.90	4	1.19	-	-	-	S	
504B	9.3	5.88	55	14.5	5.8	200	-	T	5.64	2	0.24	-	-	-	S	
507	11.3	6.01	52	15.0	5.8	200	-	T	5.53	4	0.48	-	-	-	S	
511	12.5	5.74	65	16.0	6.8	200	-	T	5.14	8	0.60	-	-	-	S	
Average fall in plasma proteins for 6 dogs—0.76 Gm. %																

\*T—for tests only.



501	15.2	5.46	69	14.5	6.5	200	+	T	4.41	4	1.05	-	-	D	Died of empyema 6 days P.O.
506	8.3	5.88	58	16.0	6.1	200	+	T	5.14	17	0.74	-	-	D	Died of empyema 18 days P.O.
510	10.3	5.53	62	14.0	5.6	200	+	T	4.31	2	1.21	-	-	D	Died of distemper 5 days P.O.
Average fall in plasma proteins for 3 dogs—1.00 Gm. %															
Average fall in plasma proteins for 9 dogs—0.84 Gm. %															
527	13.1	6.44	46	11.5	5.4	400	-	T	4.86	3	1.58	-	-	S	
541	13.3	5.25	56	15.0	5.9	400	-	T	5.91	2	0	-	-	D	Died of tension pneumothorax 7 days P.O.
546	22.2	6.05	61	16.5	6.4	400	-	T	5.70	2	0.35	-	-	S	
558	9.7	5.31	67	14.0	6.8	400	-	T	5.28	2	0.03	-	-	S	
560	20.7	6.23	71	16.0	7.4	400	-	T	5.50	4	0.73	-	-	D	Died of tension pneumothorax 5 days P.O.
573	9.6	5.79	61	14.0	6.4	400	-	T	5.33	1	0.46	55	13.0	5.8	S
Average fall in plasma proteins for 6 dogs—0.52 Gm. %															
540	9.0	4.97	68	12.5	6.1	400	+	T	5.39	2	0	-	-	D	Died of empyema 7 days P.O.
547	9.5	5.50	52	15.5	5.8	400	+	T	4.24	2	1.26	-	-	D	Died of empyema 5 days P.O.
557	15.3	5.39	51	12.0	5.6	400	+	T	4.86	1	0.53	-	-	D	Died of distemper 2 days P.O.
561	9.6	5.64	64	15.5	6.6	400	+	T	5.14	2	0.50	-	-	D	Died of distemper 3 days P.O.
331	15.1	5.74	58	15.0	6.4	400	+	T	5.31	3	0.43	-	-	D	Died of empyema 6 days P.O.
570	14.3	5.80	62	15.5	6.8	400	+	T	5.07	1	0.73	-	-	D	Died of distemper 3 days P.O.
572	8.4	5.72	56	11.0	6.2	300	-	T	4.80	12	0.92	45	12	5.8	S
Average fall in plasma proteins for 7 dogs—0.62 Gm. %															
Average fall in plasma proteins for 13 dogs—0.58 Gm. %															
<i>Left pneumonectomy with serum intrapleurally and blood transfusion in 8 dogs</i>															
575	10.4	5.09	60	14.0	5.9	Serum — 200 c.c.	-	T	5.11	1	0	55	14.0	5.7	S
I.P.															
Blood															
100 c.c.															
581	6.7	5.98	54	15.0	5.8	I.V.	-	T	5.25	6	0.73	58	16.0	6.4	S
582	10.7	6.36	60	16.0	6.3	"	-	T	5.14	2	1.11	64	16.5	6.7	S
594	10.4	5.84	59	15.5	6.1	"	-	T	5.46	6	0.38	64	16.0	6.5	S
597	15.9	5.25	58	15.0	5.9	"	-	T	5.42	2	0	62	16.0	6.1	S
Average fall in plasma proteins for 5 dogs—0.44 Gm. %															
574	14.2	4.85	54	13.0	5.6	"	+	T	4.35	2	0.51	56	15.0	5.9	D
576	10.2	5.65	59	15.0	6.2	"	+	T	5.11	5	0.53	63	15.5	6.4	D
557	9.8	4.06	51	13.0	5.4	"	+	T	4.31	1	0	-	-	D	Died of distemper 2 days P.O.
Average fall in plasma proteins for 3 dogs—0.34 Gm. %															
Average fall in plasma proteins for 8 dogs—0.41 Gm. %															

TABLE VI  
REDUCTION OF PLASMA PROTEINS BY LUNG RESECTION AND ITS REPLACEMENT IN FOUR GOATS\*

GOAT NO.	INITIAL WEIGHT (KG.)	INITIAL TOTAL SERUM PROTEIN	INITIAL HEMATOLOGIC FINDINGS		REPLACEMENT THERAPY (C.C.)	INFECTION PRESENT	PLEURAL FLUID REMOVED (C.C.)	LOWEST TOTAL SERUM PROTEIN (GM. %)	TIME FOLLOWING OPERATION (DAYS)	AMOUNT OF FALC IN P.P. (GM. %)	HEMATOLOGIC FINDINGS AT TIME OF LOWEST PLASMA PROTEIN LEVEL		DIED OR SACRIFICED	REMARKS
			HEMA-TOCRIT	HB.										
											HEMA-TOCRIT	HB.		
1	17.5	6.01	36	14.0	0	-	75	4.48	2	1.53	30	11.0	S	Left lower lobectomy. Sacrificed 4 months P.O.
2	19.3	6.74	46	12.5	0	-	0	4.97	2	1.77	42	12.0	S	Left pneumonectomy. Sacrificed 6 months P.O.
3	32.3	6.36	46	13.0	Serum I.V. 450 c.c.	-	0	5.64	1	.72	40	12.0	S	Left pneumonectomy. Sacrificed 6 weeks P.O.
4	34.7	6.53	50	13.5	Serum I.P. 400 c.c.	+	0	5.21	2	1.32	45	13.0	S	Left pneumonectomy. Small encapsulated empyema. Sacrificed 7 weeks P.O.

\* Because of the scarcity of this animal as well as the increased cost as compared to dogs, only four goats were used in this problem. A definite hypoproteinemia resulted in the first two animals (control) following lung resection. The amount of plasma protein fall was materially reduced in the last two by intravenous and intrapleural administration of serum. In Goat 4 the factor of infection was present but in a very mild degree. This, added to the route as well as the amount of replacement therapy (I.P.), probably accounts for the increased fall in plasma proteins over that seen in Goat 3.

believed that there was more or less of a balance between the proteins of the blood and the body proteins—an ebb and flow or dynamic equilibrium. Madden and co-workers demonstrated in dogs that the plasma protein building material may be depleted in two to six weeks by plasmapheresis.<sup>4</sup> It is quite readily conceivable that a considerable depletion of reserve body proteins may take place in patients with long-standing infections, where constant suppuration is present. The rapid fall in blood plasma proteins from 7.53 to 4.62 or a total of 2.91 Gm. per cent, within twenty-four hours, in the first case cited would strongly suggest that the reserve store of proteins in this individual had been markedly lowered.

Some of the deleterious effects of hypoproteinemia have been demonstrated by animal experimentation. Thompson, Ravdin, and Frank<sup>5</sup> found that the normal processes of wound repair could be greatly retarded by experimentally producing hypoproteinemia in the dog. In a further investigation, Thompson, Ravdin, Rhodes, and Frank<sup>6</sup> used lyophil plasma in the correction of hypoproteinemia and found that the retardation in wound healing associated with lowered blood proteins in dogs could be averted by restoration of the serum protein to normal levels immediately after operation. Ravdin<sup>7</sup> believes that there is "no such thing as a critical level of the plasma protein at which edema becomes manifest."

The influence of hypoproteinemia on the development of postoperative infections, either in the lungs or at the site of operation must be considered. Cannon and his associates,<sup>8</sup> from experiments on rabbits, found a diminution of agglutins produced and increased susceptibility to infection in rabbits with hypoproteinemia as compared to their litter-mates with normal blood protein levels.

The clinical application of these data at the present time is quite obvious. In civilian practice, operations within the chest for tumor or infection should be preceded by blood or serum transfusion in the presence of a lowered blood plasma protein. Likewise, casualties on the battlefield frequently have lost considerable quantities of blood and should be carefully investigated for evidence of hypoproteinemia before making operations which in themselves would aggravate the already lowered blood proteins. Loss of additional protein during and following operation should be expected and replacement of the same planned for in advance. Not infrequently the amount of blood loss at operation is far underestimated. White and Buxton,<sup>9</sup> from a study of 108 operations on patients, found the average loss following various chest operations to be as follows: Thoracoplasty, 725 c.c.; lobectomy, 1607.5 c.c.; and pneumonectomy, 1458.8 c.c. The maximum loss for these operations was as high as 2895.3 c.c. These figures compare favorably with those obtained from a similar study made on patients at the University of Chicago Clinics.

In some recent publications a word of warning has appeared regarding the use of large blood transfusions. Gibbon and associates<sup>10</sup> demonstrated by experiments in cats that large transfusions following the resection of approximately two-thirds of the lung tissue caused death due to pulmonary edema. His experiments employed a bilateral operation and removal of a higher per cent of the total lung volume at one time than is advisable clinically. Ivy and co-workers<sup>11</sup> in experiments on dogs demonstrated that replacement of severe blood loss (60 per cent of blood volume) with citrated blood, if given rapidly (within five minutes), was fatal in a high percentage of animals, and cautioned against the giving of large transfusions rapidly.

These experiments, in themselves, do not preclude the use of adequate blood or plasma in replacement of blood and serum lost at operation or otherwise. However, they might tend to influence some surgeons to use smaller amounts of blood than would be advisable for the patient. In this connection it has been shown by Weech and Ling<sup>12</sup> that the administration of large amounts of saline solution intensified the deleterious effects normally produced at the same level of lowered plasma protein. In other words, a latent edema could be developed into severe edema by the administration of a large quantity of saline solution intravenously.

#### SUMMARY AND CONCLUSIONS

1. Blood plasma proteins were reduced by 33½ per cent to a significantly low level (approximately 4.0 to 4.25 Gm. per cent) following the resection of the lung in dogs. This reduction of the normal concentration persists for as long as ten days.

Several factors contributed to the fall in plasma proteins, namely, the removal of lung tissue, the thoracotomy wound, anesthesia, and infection.

2. Marked reduction in blood plasma proteins following resection of the lung was obviated by adequate replacement of protein loss. Replacement therapy consisted of the administration of blood or serum intravenously or serum intrapleurally. Both replacement materials and routes of administration were equally effective when the materials were given in adequate amounts.

#### PROTOCOL 1.

Dog 389.—Hypoproteinemia following left total pneumonectomy.

10/19/42. An 8.5 kg. mongrel had the preoperative blood studies made as seen in the accompanying summary. Under morphine 0.015 Gm. and intratracheal ether anesthesia an incision was made along the course of the left fifth interspace. After dividing the muscles along the course of their fibers, the pleural cavity was opened through the left fifth interspace. The three veins and one artery of the left lung were doubly ligated with silk and divided between ligatures. The left primary bronchus was mobilized and after closing this bronchus by three sutures (Fig. 3) the bronchus was divided. The mucosa was then cauterized with a 35 per cent solution

## PROTOCOL 1

## HYPOTHEINEMIA FOLLOWING TOTAL PNEUMONECTOMY—Dog 389

[illegible]

of silver nitrate and the end closed with a running stitch of silk. The pleura of the chest wall was then irritated by massaging with a sponge (2 by 2 inches) which was left in the pleural cavity.

Closure was made using two paracostal stitches and a running stitch of silk for the intercostal structures. The muscles of the chest wall were reapproximated with continuous silk sutures, the same material being used for the subcutaneous tissues and for the skin.

With the closure of the pleural cavity, air was aspirated from the pleural space by means of a catheter brought out through the wound. When the pressures were found to be normal, the catheter was removed. The animal was returned to the kennel in good condition.

10/20/42. The animal appeared to be well, but ate little. The plasma proteins were found to have fallen from 5.53 to 5.14 Gm. per cent. The temperature was elevated.

10/21/42. Plasma proteins had fallen still further to 4.86 Gm. per cent. The general condition was good, but the dog ate little.

10/22/42. A still further reduction in plasma protein was noted to a level of 4.24 Gm. per cent and 90 c.c. of a serosanguineous fluid were removed from the pleural space. It contained a concentration of 4.63 Gm. per cent of protein.

10/26/42. Dog's plasma protein level was still below normal, but had risen to 5.11 Gm. per cent by this time. It continued below normal, as seen in the summary, for another two days and had returned to the preoperative level by the tenth day following operation.

Fluoroscopic and x-ray examinations made on Oct. 20, 22, 25, and 29 revealed fluid in the left pleural space. Aspiration of this fluid on Oct. 20, 22, 26, and 29 revealed no evidence of infection on culture. The wound healed by primary intention.

The animal was sacrificed on 11/5/42, seventeen days following operation. The bronchial stump was solidly healed and little pleural fluid remained. As shown by the summary for this animal, a hypoproteinemia of a considerable degree developed. It was seen to begin by the first day following operation and persisted for ten days, being most marked on the third day.

## PROTOCOL 2.

Dog 575.—Replacement of blood protein loss following left total pneumonectomy.

5/3/43. A 10.4 kg. mongrel had preoperative blood studies made as shown in the accompanying summary. Under ether anesthesia, preceded by morphine, an incision was made over the course of the left fifth interspace. The muscles were divided in the direction of their fibers and the pleural cavity entered through the left fifth interspace. The three veins and one artery of the left lung were mobilized, doubly ligated with silk, and divided between ligatures. The left primary bronchus was mobilized and three silk sutures applied as illustrated in Fig. 3. The bronchus was then divided and the mucosa cauterized with a 35 per cent solution of silver nitrate. The end of the bronchus was then closed with a running stitch of silk. The pleura of the chest wall was then irritated by massaging with a gauze sponge (2 by 2 inches) which was then left in the pleural cavity. The chest wound was closed using two paracostal sutures of silk and a running stitch of silk for the intercostal structures. The muscles of the chest wall were then approximated with silk sutures and the same material was used for the subcutaneous tissues and skin. As the wound was being closed, air was removed from the pleural space and replaced with 180 c.c. of serum, the intrapleural pressure being normal when the catheter used for this was removed. Following this, a transfusion of 100 c.c. of whole blood was given. The animal was returned to the kennel in good condition.

## PROTOCOL 2

## REPLACEMENT OF BLOOD PROTEIN LOSS FOLLOWING TOTAL PNEUMONECTOMY—Dog 575

Date	5/3/43	5/4/43	5/5/43	5/6/43	5/7/43	5/8/43	5/11/43	5/18/43
Weight	10.4			10.8				10.3
Temperature	100.4° F.	103.2° F.	102.8° F.	103.2° F.	103.8° F.	103.6° F.	103.8° F.	—
Blood								
Hemoglobin (Gm.)	14	—	—	14	—	—	14	—
Red cells (m.)	5.9	—	—	5.7	—	—	5.7	—
Hematocrit (%)	58	—	—	55	—	—	55	—
Plasma protein	5.09	5.30	—	5.46	5.29	5.74	5.80	—
Thoracentesis	—	—	for culture	—	for culture	20 c.c. removed	—	—
Culture	—	—	sterile	—	sterile	sterile	—	—
Fluoroscopy	—	Fluid on left side only	—	—	Some shift of the heart to the right	Same	No shift of mediastinum	—
Wound	Healing by primary intention							
General condition	Remained good							

Left total pneumonectomy on 5/3/43. Dog received 180 c.c. of serum intrapleurally and 100 c.c. of blood intravenously following operation. When sacrificed two weeks later, 100 c.c. of serum were found in the left pleural space.

5/4/43. The animal was in good condition, but ate little. The plasma proteins had risen slightly from the preoperative level.

5/8/43. Plasma proteins continued to rise and the fluid removed from the pleural space remained sterile on culture. The wound healed by primary intention and the dog's general condition remained good. The preoperative level of plasma proteins was a low normal and by eight days following operation had risen 0.75 Gm. per cent.

5/18/43. The animal was sacrificed. The bronchial stump was found to be solidly healed. Approximately 100 c.c. of serum were found in the left pleural space.

We wish to thank Mr. Magnus Harding and Miss Nancy Corbin for technical assistance and protein determinations made in this study.

#### REFERENCES

1. Peters, John P., and Van Slyke, Donald D.: Kjeldahl Method for the Determination of Blood Plasma Proteins. Quantitative Clinical Chemistry, Baltimore, Md., 1932, Williams & Wilkins, P. 516.
2. Barbour, H. G., and Hamilton, W. P.: The Falling Drop Method for Determining Specific Gravity, *J. Biol. Chem.* 69: 625-640, 1926.
3. Madden, Sidney C., and Whipple, George, H.: Plasma Proteins: Their Source, Production and Utilization, *Physiol. Rev.* 20: 194, 1940.
4. Madden, Sidney C., George, W. E., Waraich, G. S., and Whipple, G. H.: Blood Plasma Protein Regeneration as Influenced by Fasting, Infection and Diet Factors, *J. Exper. Med.* 67: 675, 1938.
5. Thompson, W. D., Ravdin, I. S., and Frank, I. L.: Effect of Hypoproteinemia on Wound Disruption, *Arch. Surg.* 36: 500, 1938.
6. Thompson, W. D., Ravdin, I. S., Rhodes, J. E., and Frank, Irving, L.: Use of Lyophile Plasma in Correction of Hypoproteinemia and Prevention of Wound Disruption, *Arch. Surg.* 36: 509, 1938.
7. Ravdin, I. S.: Hypoproteinemia and Its Relation to Surgical Problems, *Ann. Surg.* 112: 576, 1940.
8. Cannon, Paul R., Chase, William E., and Wissler, Robert W.: The Relationship of the Protein Reserves to Antibody Production. In press.
9. White, M. L., Jr., and Buxton, Robert, W.: Blood Loss in Thoracic Operations, *J. Thoracic Surg.* 12: 198, 1942.
10. Gibbon, John H., Jr., Gibbon, Mary H., and Kraul, A. B.: Experimental Pulmonary Edema Following Lobectomy and Blood Transfusion, *J. Thoracic Surg.* 12: 60, 1942.
11. Ivy, A. C., Breengard, H., Stein, I. F., Jr., Grodine, F. S., and Dutton, D. F.: The Effect of Various Blood Substitutes in Resuscitation After an Otherwise Fatal Hemorrhage, *Surg., Gynec. & Obst.* 76: 89, 1943.
12. Weech, A. A., and Ling, S. M.: Nutritional Edema. Observations on Relation of Serum Proteins to Occurrence of Edema and to Effect of Certain Inorganic Salts, *J. Clin. Investigation* 10: 869, 1931.



## ON THE MANAGEMENT OF BURNS

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**B**URNS are the trade-marks of war. Flaming arrows, the boiling pitch and tar pots, and even the modern flame throwers are practical products of war. But direct attempts to produce thermal injury are secondary in importance to the burns that result from bombings, and the accidents, including civilian disasters, that are coincidental with war.

Recently released statistics reveal that 60 per cent of the casualties at Pearl Harbor were the result of burns. Slightly lower percentages are reflected in the statistics available following the bombings of Britain. And yet, in spite of a clearer understanding of the pathologic effect of burns, the percentage of deaths from burns has not been appreciably reduced in the past years. Those patients suffering from burns fall into two broad classes, the quick, and the dead. The quick survive primarily because of the presence of enough intact skin compatible with life. From a practical viewpoint, there are but two types of burns, the third degree burns and the remainder. The only factors that enter into any burn are the extent and the degree. The extent of "the remainder" may cause them to fall into the "third degree type" from a standpoint of therapeutics, for in truth, the only type of lesion which presents a real test is the third degree burn. Because of this fact, the adequate management of burns revolves about two main trends of thought—the general treatment of the patient and the local treatment of the burned area. The primary object of this discussion is to emphasize further the primal importance of the first of these tenets—the general treatment of the patient—and to sublimate the local treatment of the burned area, even to ignore it to such an extent that one can say that almost any type of local treatment which will do no further harm will suffice in first degree and second degree burns, if they are not too extensive, and ultimate recovery will result not because of the local treatment, but in spite of it.

It is an accepted fact that from 60 to 75 per cent of all burn patients that die, do so because of peripheral vascular failure. In treating patients with burns it is not necessary to differentiate between primary and secondary shock since the only clinical difference between burn shock and that due to other causes is in the degree of immediate hemocoagulation. Although the classical appearance of the patient in

"shock" in the terminal phases of many diseases is accepted as a normal occurrence as the result of a sequence of pathologic events, the use of this term shock, actually indefinable in itself, has served to picture a clinical entity rather than indicate its mechanism, particularly following injury. It has been apparent since the days of Harvey that an adequate circulation of blood is dependent upon a proper output from the heart. This cardiac output obviously may be limited by an increase in the vascular bed or by a diminution in the volume of the blood. Adequate experimental evidence is at hand to show conclusively the sequence of events in the production of shock following burns. A burn produces local capillary injury with an immediate loss of some of the components of the blood, chiefly plasmalike substances in the tissues at the site of the burn. There is, in addition, loss of plasma from the injured skin surfaces. These two factors alone account for a definite loss in total blood volume. When this loss becomes sufficient—and this loss is immediate and quantitatively rather great—to be incompatible with the maintenance of an adequate circulation, the resultant anoxemia of the tissues throughout the body per se produces an increase in the permeability of the capillary walls. A general loss of electrolytes, water, and protein from the blood is inevitable and completes the vicious cycle. The signs of peripheral vascular failure, the vasoconstriction as evidenced by the ashen or slightly cyanotic skin, the profuse sweating, and the hyperpnea are merely evidences of the sole compensatory mechanism the body possesses to offset this lack of adequate total blood volume. The emergency nature of this impending condition must be emphasized. The need for prompt and adequate treatment to offset this condition before irreparable anoxic tissue damage occurs and pathologic changes in the viscera are established, that are irreversible once established, is essential, imperative, and requires true clinical "teamwork."

Therapeusis is directed primarily toward the two outstanding pathologic conditions that present themselves in every severe burn—the lack of plasma in the circulation reflected in inadequate blood volume and the generalized anoxemia of the tissues.

Certain elementary general therapeutic measures are not utilized to their fullest extent in many instances. The immediate use of morphine in all conscious patients is clearly indicated and should be given in large enough amounts to produce its physiologic effect. The correct answer to "how much?" is "enough" and the two "yardsticks" are the freedom from pain and the respiratory rate. In the presence of pain, morphine should be given in  $\frac{1}{4}$  gr. doses, until the respiratory rate drops to 12 per minute. The adequate administration of morphine is the first step toward the production of rest, an all-important phase in offsetting impending "shock." This should be followed immediately by physical immobilization of the burned parts. That the primary function of all dressings regardless of the type of injury is that of

providing physiologic rest is an accepted fact; attention is directed to the rest that results from immobilization of a traumatized area, be it thermal in origin or not. Too much stress cannot be placed upon the immediate local treatment of burns as an integral part of the general treatment. This immobilization to prevent further shock can only be brought about through the use of adequate dressings using cotton, mechanics waste, folded newspapers, and even splints to provide the necessary bulk. While "rest" is thus being brought about, adequate provision for the control of the loss of body heat must be considered as the second feature in the general treatment of burns. Warmth, but not heat, is essential. The skin is a most important organ and its chief function is the major role it plays in the control of the loss of body heat. Clinical evidence of this often overlooked factor is the persistent subnormal temperatures of patients upon admission that have suffered major losses of skin-surface. It is imperative that normal body heat be retained and maintained at all times to avoid impending shock. Climatic conditions obviously offset the control of this phase of treatment; hot climates obviously differ from the cold of the polar regions. The presence of bulky heat-retaining dressings in the tropics must be occasionally counteracted by transporting the patients to a cold room to prevent hyperthermia.

The most outstanding clinical feature of shock is circulatory collapse. Since the transport of oxygen is the prime function of the circulation, failure of this mechanism increases the tissue anoxemia and a vicious cycle is established. Until the cause of the shock can be removed and the blood volume restored, oxygen is the best, the only way, of combating anoxemia. To withhold this specific treatment until respiratory and tissue decompensation are apparent is a most common therapeutic error. As a specific measure, the use of oxygen to prevent tissue anoxemia and the resultant spread of the peripheral vascular failure cannot be minimized. For example, all doctors appreciate the fatal effect of even temporary cerebral anoxemia when respirations fail regardless of cause and, in this instance, artificial respiration is invariably started at once. An exact parallelism exists in burn shock. Impending tissue anoxemia is always present, which if allowed to persist will ultimately result in an increase in the capillary permeability and deepen the degree of the shock. The normal percentage of alveolar oxygen can be doubled by the administration of oxygen through a nasal catheter at the rate of  $1\frac{1}{2}$  L. per minute, tripled and even quadrupled by placing the patient in an oxygen tent, and increased some five times by the administration of oxygen by means of a B-L-B mask. Obviously, the more extensive the burn, the higher the percentage of alveolar oxygen required to prevent tissue anoxemia. It must be stated, however, that although the best and most economical method of administering oxygen is by means of a B-L-B mask, this method of choice is not practical unless the patient is able to understand and cooperate,

or is wholly unconscious. Experience has shown that the struggles of the irrational, uncooperative patient while using a B-L-B mask may do more ultimate harm than the good that comes from the administration of oxygen.

The most important single step in the treatment of burns is the intravenous administration of plasma to restore the normal total blood volume. The use of plasma in each instance must be quantitative and individualized for each burned patient. To calculate the dosage of plasma, one of several simple formulas may be used. The clinical method provides for the administration of plasma in sufficient quantities to maintain adequate peripheral circulation, as shown by testing the bleeding time from a needle prick of the ear. This method is *always* available. The first-aid formula of Berkow advocates the use of 50 c.e. of plasma for each per cent of the body surface involved in a deep burn. When adequate laboratory facilities are available, the hematocrit method as suggested by Harkins has proved most valuable and in addition gives one a yardstick as to the progress of the individual case. This method calls for the administration of 100 c.e. of plasma for every point exceeding 45, the normal hematocrit for adults, except when the total proteins fall below 600 mg., when an additional 25 per cent of plasma must be given to cover this deficit.

It is not unusual for many of the major peripheral veins to be thrombosed as the result of burns. Thermal injury to the median ante-cubital fossae, the ankles, and the hands is most distressing and common, but the jugular and scalp veins are frequently not involved. The sternum is always available. The intravenous administration of plasma is extremely trying on the veins themselves and thrombosis eventually results. The rate of flow of plasma should be relatively slow but continuous. The use of a large bore needle and a three-way by-pass stopcock to allow continuous intravenous administration of plasma in the severe cases is ideal.

Two crystalloids, the chlorides and the carbohydrates, must be given to all patients suffering from burns. It has been shown that 10 Gm. of chloride per twenty-four hours will keep the average adult in chloride balance. Enough carbohydrate in the form of sugar must be given to protect the liver against undue depletion of the liver glycogen. It is absurd to use the few remaining superficial veins that are so essential for the administration of plasma for the parenteral administration of either chlorides or carbohydrate. The installation of a nasal catheter for feeding and for the administration of both chlorides and carbohydrates is essential. A No. 16 soft rubber urinary catheter has the physical advantages of hanging free in the esophagus; the presence of its normal funnel-shaped tip easily admits the entrance of a cork to block the regurgitation and acts as a buttress for the adhesive to hold it in place. In this fashion a calculated high protein diet containing

vitamins, electrolytes, etc., is assured at all times as well as an adequate caloric and fluid intake without resorting to parenteral therapy.

Diet should be high protein in character from the onset as there is an abundance of experimental and clinical evidence that focal necrosis of the liver will result from a protein-free diet just as easily as from continuous lowered serum protein levels of the blood.

Actually the administration of these crystalloids by the intravenous route (the "popular" route can produce irreparable damage) merely "washes out" the plasma from the total blood volume at an alarming rate and should not be employed.

The local treatment is directed at the immobilization of the burned parts to prevent further shock, the prevention of sepsis, the prevention of contractures, and the assistance in epithelization.

Most of the patients with burns who die after a ten-day survival, die from sepsis. The use of 2 Gm. of sulfadiazine as soon as practical and repeated in eight hours followed by 1 Gm. every six hours has its proponents who insist that the blood level of 7.5 mg. per cent should be maintained for the first two weeks. Contractures are prevented only by early skin grafting. Splinting will not prevent contractures nor will the application of plaster casts alter this pathologic result of burns. Such procedures only mask the true situation and all treatment should be directed toward the preparation of the area for grafting at the earliest possible moment to prevent this unfortunate complication. Application of pressure dressings remains the best known procedure irrespective of the application of many so-called epithelial stimulants such as scarlet red to encourage epithelial spread and regeneration. All burn cases are candidates for tetanus and must be treated accordingly. The local use of tannic acid sprays, the various aniline dyes, the sulfonamides, the tub baths, and the Bunyan envelopes, although staunchly defended by their respective proponents, minor factors and may be dismissed without further comment. The use of fine mesh xeroform gauze held in place with firm and bulky dressings is my method of choice in handling these local trivia.

The most serious complication is the presence of fractures and in a severely burned individual this complex taxes one's ingenuity and must be dealt with accordingly in an individualized fashion.

Tracheotomies in those patients who have inhaled flames are essential and lifesaving. If there is any question as to the need for this operation, it should be carried out without delay. The time to perform a tracheotomy is before it becomes urgent from the clinical signs.

An ophthalmologist must check the eyes of all patients burned about the face as soon as practical following admission, confirm his findings by a second examination within twelve hours, and include them in the record.

Special nurses who not only assist in the administration of plasma and the local care of the wounds but who are trained to pay particular

attention to the intact skin are invaluable. Similarly, the roles of the neuropsychiatrist and the Red Cross worker cannot be minimized. Inasmuch as burns rank close to the common cold and fractures from a standpoint of hospital days, these seemingly endless days must be planned in a thoughtful fashion for the patient convalescing from burns.

Recent experimental evidence indicates that barbiturates act as a specific in the prevention of shock in burn cases, but there are no clinical data at hand to substantiate this fact at this writing. In a similar vein, the use of adrenal cortex has its advocates. Rhoades, Wolff, and Lee have experimental evidence to show its efficiency. At present this is a nonstandard drug and is not available.

In conclusion, let it be stated that the principles of the treatment must receive primary consideration in the management of severe burns and one's attention must not be distracted by the employment of local "specifics" classed by some as "trivia."

This apologia represents the reflections obtained from a year's experience with burns in the Middle East without any recourse to the current literature which must abound with notes on this all-important subject.

## SECONDARY CARCINOMA OF THE MANDIBLE

### AN ANALYSIS OF SEVENTY-ONE CASES\*

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THE likelihood of success in treating secondary carcinoma of the mandible is not as infrequent as one might think from isolated experiences, or from the literature.<sup>1</sup> Secondary neoplasms of bone are comparatively frequent,<sup>2, 3, 4</sup> as many primary tumors are responsible for bone involvement; the incidence of metastasis to the mandible appears to be rare, as few references<sup>5, 6, 7</sup> to metastatic carcinoma of the mandible are noted in the literature. Stern and Shephard<sup>10</sup> summarized from the literature fifty-five cases of metastatic involvement of the jaw, and reported one case of metastasis to the mandible from a bronchiogenic carcinoma.

The following analysis of seventy-one case records of secondary invasive carcinoma of the mandible treated at the University of Minnesota Hospitals and the Tumor Clinic,<sup>11</sup> from 1924 to 1943, include malignancies secondary to primary carcinoma of the lip, buccal mucosa, lower alveolar process (gingiva), and the floor of the mouth. This study was not undertaken as a basis for any broad conclusions, but rather to ascertain the results of methods employed by surgeons at the University of Minnesota Hospitals.†

#### GENERAL CONSIDERATIONS

*Age.*—The youngest patient in this group was 48 years of age and the oldest 84. Twenty-nine per cent were in the sixth decade and 30 per cent in the seventh.

*Sex.*—There were eight women and sixty-three men. The average age of the men was 65 years and of the women 63.

*Stage of Disease.*—The cases were studied as a group of seventy-one patients and divided as to the topographical location of the initial lesion and classified according to the extent or stage of the disease as suggested by Howes and Bernstein.<sup>12</sup> Stage I: A lesion 1.5 cm. or less in diameter and confined to its local anatomic structure as far as can be determined by palpation and microscopic examination at the time of treatment. Stage II: A lesion over 1.5 cm. in diameter, still limited to the local

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\*Data were compiled by the author prior to active military service

†The operations reported herein were performed by numerous surgeons, the chief responsibility for the care of these cases devolved successively upon Doctors W. T. Peyton, J. R. Paine, and latterly myself. Currently, Dr. Clarence Dennis is supervising the care of these cases in the surgical clinic.

area. Stage III: A lesion with local extension but no evidence of regional metastases, that is from lip to gingiva and mandible, from buccal mucosa to gingiva and mandible. Stage IV: A lesion with local extension and regional lymph node metastases confirmed by histologic examination.

TABLE I

CLASSIFICATION OF THE PRIMARY LESIONS ACCORDING TO LOCATION AND STAGE OF INVOLVEMENT

STAGE	LIP	BUCCAL MUCOSA	GINGIVA	FLOOR OF THE MOUTH
I. Localized lesion up to 1.5 cm. in diameter	8	1	4	2
II. Larger than 1.5 cm. without local extension	9	9	10	1
III. Localized extension with bone invasion	0	2	11	0
IV. Local extension and lymph node metastases	0	1	11	2

*Symptoms.*—More than half of these people were unaware of an oral lesion of a serious nature until pain, ulceration, hemorrhage, or metastases as a submandibular swelling was experienced. In the clinical Stage III cases, mandibular bone pain, or toothache, was the principal complaint which obliged the patient to seek medical or dental attention.

*Etiologic Factors.*—Chronic intraoral irritation in some form was found in all of the group. Oral sepsis, mild or severe, and dental caries were present to a degree in most of the patients. Beiswanger<sup>13</sup> reported 95 per cent of 160 cases of oral carcinoma associated with dental sepsis. Ill-fitting dentures of five patients were thought to be directly responsible for their gingival carcinoma. Two men were known to have carried tobacco quid for years at the site of a buccal lesion. Intraoral leucoplakia was recorded as a precancerous lesion in eight (11 per cent) of the patients. Complete data were lacking in many of the charts, and it is possible that the occurrence of all etiologic factors was considerably larger.

Approximately 40 per cent of the patients in this group had been edentulous for years, and in many instances attributed their disaster to earlier dental extractions. Malassez<sup>14</sup> pointed out that epithelial cell rests of the periodontal membrane, when stimulated by inflammation, infection, or trauma, were responsible for the development of radicular cysts in the edentate as well as the dentate jaw. Thoma<sup>15</sup> reported a carcinoma of the mandible, grade II, arising from the periodontal membrane at the apex of a third molar and editorially states, "A small amount of membrane attached to an extracted tooth may be just a remnant of the dental follicle, but it may also be a new growth; adenomatoma may form in the young, or carcinoma may form after middle age from remnants of tooth germs."



*Delay in Diagnosis and Treatment.*—Delays were observed with consistent frequency as in other malignancies.<sup>16</sup> Smith<sup>17</sup> determined an average delay of eight months for oral carcinoma, and Martin and Sugarbaker<sup>18</sup> determined a delay of five months in patients with carcinoma of the floor of the mouth.

In this series the patient endured a delay of several months prior to diagnosis or appropriate treatment. There were seventeen patients with lip cancer, which averaged a delay of 12.4 months before treatment; eleven patients with carcinoma of the buccal mucosa with a delay of 13.5 months; twenty-one patients with gingival lesions averaged a delay of 9.5 months, and two patients with cancer of the floor of the mouth suffered a delay of 6.5 months. The average delay for fifty-one cases was 8.4 months.

*Responsibility for Delay.*—The fault lies jointly with the physician and the patient. The common mistake of the patient was his unexplained procrastination. He may have suspected a serious condition, but delayed investigation until pain or disability forced him to seek medical care. A further serious error was a 10 per cent incidence of patients accepting cancer therapy from unapproved sources, and unfortunately an equal number of cases received unacceptable medical treatment.

The physician's responsibility for delay in this group of patients with oral carcinoma was often shared by the dental surgeon. The most common cause for delay in instituting proper treatment was the failure of both the dentist and the physician to suspect a malignant lesion. Only 10 per cent of the patients were promptly referred by the dentist or physician to an appropriate source of therapy.

*Differential Diagnosis.*—In the present study there was no real problem of differential diagnosis because all the lesions were biopsied and examination of the tissues revealed carcinoma of squamous cell origin. However, in fifteen instances an opportunity to establish an early diagnosis was overlooked as eleven patients had had extractions of teeth in the presence of intraoral carcinoma; the dentures of two patients had been revised to accommodate the growth of a tumor, and one patient was given prolonged treatment for a Vincent's infection.

Gettinger's<sup>19</sup> illustrative account stressed the importance of cooperation between individuals responsible for the diagnosis of intraoral lesions and the pathologist. Darlington,<sup>20</sup> in an analysis of 1,150 specimens of tissue removed for histologic examination, found 474 tumors; 227 epuli and polyps, 158 radicular cysts and granulomas, 24 dentigerous cysts, 12 ameloblastomas, and 53 carcinomas.

#### CARCINOMA OF THE LIP

There were seventeen patients in this group and all had their primary growth on the lower lip. At the time of the initial treatment which

consisted of surgical excision or radiation, or both, eight presented Stage I lesions, and nine had Stage II growths. Seven Stage I lesions were controlled for an average of 4.3 years, and four of these for the duration of the disease. Four men with primary Stage II disease, uncontrolled by treatment, returned with Stage IV involvement; one, after a duration of four years, presented an inoperable growth, and three, after two, seven, and nine years of temporary control, refused surgical treatment. Six Stage II growths were controlled for an average of 4.6 years, and two were controlled permanently.

TABLE II

CLINICAL SUMMARY OF THIRTEEN PATIENTS SUBJECTED TO PARTIAL MANDIBULAR RESECTION

(Primary Carcinoma of the Lip)

Case number	1	2	3	4	5	6	7	8	9*	10	11	12	13
Age	84	80	76	64	59	58	54	79	60	66	52	51	50
Stage of initial lesion	I	I	I	I	I	I	I	II	II	II	II	II	II
Treatment of primary	S-R	R	R	R	S-R	R	S	R-S	S	S	S	R	S-R
Years primary controlled	5	3	2	6	4	5	5	1	3	13	2	5	3
Stage at time of resection	III	III	IV	IV	IV	IV	IV	IV	IV	III	IV	IV	IV
Resection years after onset	2	3	2.5	5.5	4	5	5	1	3	5	2	3	3
Tracheotomy	+	-	-	-	+	+	+	-	-	-	-	-	-
Mandibular resection	+	-	-	-	-	-	+	+	-	+	-	+	+
Hemisection and disarticulation	-	+	+	+	+	+	-	-	+	-	+	-	-
Suprahyoid dissection	+	-	+	+	+	+	-	-	-	-	-	+	-
Supra-omohyoid dissection	-	+	-	-	-	-	-	-	+	-	+	+	-
Oral cutaneous fistula	+	+	+	+	+	-	+	-	+	+	+	-	-
Postoperative radiation	-	-	+	+	+	+	+	-	-	-	-	+	-
Postoperative death	-	+	-	-	-	-	-	-	-	-	-	-	+
Alive free of disease (yr.)	3†	.	.	.	.	.	.	.	2	.	.	.	.
Dead free of disease (yr.)	.	.	.7	.	.	.	.	.	T	8	.	.	.
Alive with disease (yr.)	.	.	.	.	.	.	.	.	T	.	.	.	.
Dead with disease (yr.)	.	.	.	.5	.2	1.5	1	1	T	.	.	2	.

\*Female.

†Last follow-up record of patients completed February, 1943.

T, Patient untraced.

Thirteen patients (Table II) accepted a one-stage partial mandibulectomy which varied in extent from segmental mandibular resection with a suprahyoid neck dissection to a hemisection and disarticulation of the mandible with a supra-omohyoid dissection and sacrifice of large portions of the cheek and lips. Three patients returned two, three, and five years after initial treatment, with Stage III carcinoma, and ten returned one to five years after initial therapy, with Stage IV disease.

#### CARCINOMA OF THE BUCCAL MUCOSA

There were thirteen patients in this group. One Stage I lesion was controlled for one year, while nine Stage II lesions were arrested for

an average of 3.9 years; two were permanently controlled. All of these patients were operated upon for secondary carcinoma of the mandible, except a 62-year-old woman who presented an inoperable Stage IV growth with extensive metastases which was first noticed nine months previously as a "canker sore." Palliative radiation was given, with death occurring two years after the onset of the disease.

One patient, aged 57 years (Table III) presented a Stage II carcinoma treated by radiation and surgery, was well for sixteen years, then suffered a recurrence which was treated by a hemisection of the mandible and disarticulation with a supra-omohyoid cervical lymph gland dissection and postoperative radiation therapy. At the time of the last follow-up (February, 1943) he was alive, with a recurrence.

TABLE III

CLINICAL SUMMARY OF TWELVE PATIENTS SUBJECTED TO PARTIAL MANDIBULAR RESECTION

(Primary Carcinoma of the Buccal Mucosa)

Case number	1	2	3	4	5	6	7	8	9	10	11	12
Age	53	75	74	71	70	65	64	57	50	48	54	70
Stage of initial lesion	I	II	II	II	II	II	II	II	II	II	III	III
Treatment of primary	R	S-R	S-R	S	S-R	S-R	S-R	R-S	R	R	S	S
Years primary controlled	1	2	1	2	1	.5	2	18	2	1	15	.5
Stage at time of resection	III	IV	IV	IV	III	III	III	IV	III	III	III	III
Resection years after onset	1	5	7.5	5	1	1	5	16	1	1	.5	1
Tracheotomy	+	+	+	+	-	-	-	+	-	-	-	-
Segmental resection of mandible	-	-	+	-	+	-	+	-	-	+	-	+
Hemisection and disarticulation	+	+	-	+	-	+	-	+	+	-	+	-
Suprahyoid dissection	+	+	+	+	+	-	-	+	+	+	-	-
Supra-omohyoid dissection	-	-	-	-	-	+	-	-	-	-	+	-
Oral cutaneous fistula	+	+	-	-	+	+	+	+	+	-	+	+
Postoperative radiation	+	+	+	+	-	+	-	+	+	-	-	-
Postoperative death	-	-	-	-	-	-	-	-	-	+	-	-
Alive free of disease (yr.)	4	.7	.	.5	9	.	4	.	3	.	.	.
Dead free of disease (yr.)	T	T	.	.	.	14	T	.	.	.	.	.
Alive with disease (yr.)	T	T	.	.	.	.	T	2	.	.	17	.
Dead with disease (yr.)	T	T	.3	.	.	.	T	.	.	.	.	1

T, Patient untraced.

Two patients presenting primary buccal lesions with bone invasion (Stage III) were treated by surgery; one with cauterly excision and segmental resection of the mandible succumbed to the disease after a year; the other patient was submitted to a radical extirpation of the growth by means of hemisection and disarticulation of the mandible with a simultaneous unilateral supra-omohyoid dissection. He remained free of disease for fifteen years, then returned with a recurrence in the cervical skin flap employed to close the defect in the full thickness of the cheek incurred at the time of the original operation.

#### CARCINOMA OF THE GINGIVA AND ALVEOLAR PROCESS

In this group there were thirty-six cases, five of them were found to be inoperable and three patients refused surgical intervention. There

were three Stage I lesions controlled for two to four years, and eight Stage II cancers controlled for an average of 15.5 months. The trend of treatment in this small group indicates that the Stage II lesions were inadequately treated, either by surgery, radiation, or both. More extensive surgery, as shown by results of the treatment of the secondary group (Table IV), probably would have initially controlled a higher percentage of the entire group of Stage II cancers.

TABLE IV

## CLINICAL SUMMARY OF ELEVEN PATIENTS SUBJECTED TO PARTIAL MANDIBULAR RESECTION

(Primary Carcinoma of the Lower Gingiva, Stages I and II)

Case number	1	2	3	4	5	6	7	8	9	10	11
Age	63	56	50	72	72	66	65	64	64	64	31
Stage of initial lesion	I	I	I	II	II	II	II	II	II	II	II
Treatment of primary	R	R	S	R	S-R	S	S-R	R	S-R	R	R
Years primary controlled	2	4	2	2.5	1	2	.3	1.5	1	1	1
Stage at time of resection	IV	IV	IV	IV	IV	III	IV	IV	III	III	III
Resection years after onset	2	4	3	2.5	1	2	1.5	1.5	1	1	1
Tracheotomy	-	-	+	+	-	-	+	-	-	-	-
Segmental resection of mandible	+	+	+	+	-	+	+	-	-	+	+
Hemisection and disarticulation	-	-	-	-	+	-	-	+	+	-	-
Suprahyoid dissection	+	+	+	-	-	+	+	-	-	+	+
Supra-omohyoid dissection	-	-	-	+	-	-	-	+	+	-	-
Oral cutaneous fistula	-	-	+	+	-	-	+	+	-	-	-
Postoperative radiation	-	-	-	-	-	-	-	-	+	+	-
Postoperative death	-	-	-	-	-	-	-	+	-	-	-
Alive free of disease (yr.)	.	6	I	.	1	2	.5	.	16	6	4
Dead free of disease (yr.)	4	T	T	.7	T	T	.	.	.	.	T
Alive with disease (yr.)	.	T	T	.	T	T	.	.	.	.	T
Dead with disease (yr.)	.	T	T	.	T	T	.	.	.	.	T

T, Patient untraced.

There were seventeen advanced carcinomas of the lower gingiva, eleven Stage III, and six Stage IV. There was no correlation of size with duration or with extension to adjacent structures. Five of these lesions (Table V) were treated by intensive radiation prior to jaw resection.

## CARCINOMA OF THE FLOOR OF THE MOUTH

There were five cases with primary lesions in the floor of the mouth. Three lesions, two Stage I and one Stage II, were controlled for six months, and one Stage IV lesion was initially treated two years after onset by radiation and surgery (Table VI).

One patient, admitted with a Stage IV involvement, was a model of unacceptable therapy. He complained of a "canker sore" in the right anterior third of the floor of the mouth which had been present for a year. Initial treatment consisted of inadequate surgical diathermy excision. (In this connection, the accounts of Eggers<sup>21</sup> and Ochsner<sup>22</sup> may profitably be reviewed by those who occasionally must perform radical operations for cancer.) There was a prompt recurrence, treated with deep x-ray therapy, which could not be completed because of pain. Narcotic addiction quickly developed. In a few months a unilateral supra-

TABLE V  
CLINICAL SUMMARY OF SEVENTEEN PATIENTS SUBJECTED TO PARTIAL MANDIBULAR RESECTION  
(Primary Carcinoma of the Lower Gingiva, Stages III and IV)

Case number	1	2	3	4	5	6	7	8	9	10	11*	12	13	14	15	16*	17*
Age	75	74	71	70	69	68	61	59	56	54	50	76	70	67	67	64	61
Stage of initial lesion	III	III	III	III	III	III	III	III	III	III	III	IV	IV	IV	IV	IV	IV
Treatment of primary	R-S	S-R	R-S	S	S	S	S	S	S	R-S	R-S	S	R-S	S	S	S	S
Stage at time of resection	III	IV	III	III	III	III	III	III	III	III	IV	IV	IV	IV	IV	IV	IV
Tracheotomy	-	-	-	-	+	-	-	-	-	-	+	+	-	-	-	-	-
Segmental resection mandible	+	-	-	-	-	-	+	+	+	+	+	-	+	-	-	+	+
Hemisection and disarticulation	-	+	+	+	+	+	-	-	-	-	-	+	+	+	-	-	-
Suprahyoid dissection	-	-	-	-	+	+	-	+	+	+	-	-	-	-	-	-	-
Supra-omohyoid dissection	-	+	-	-	+	+	-	-	-	-	+	+	-	-	-	+	-
Oral cutaneous fistula	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	+	-
Postoperative radiation	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-
Postoperative death	-	-	+	-	-	-	+	+	-	-	-	-	-	-	+	-	+
Alive free of disease (yr.)	S	2	.	7	.	.8	.	.	.	3	.	.	2	2	.	.1	.
Dead free of disease (yr.)	S	.	.	.	.6	.	.	.	.	.	.	.	.	.	.	.	.
Alive with disease (yr.)	.	.	.	.	.	.	.	.	1.5	.	.8	.	.	.	.	.	.
Dead with disease (yr.)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

\*Female.

TABLE VI

CLINICAL SUMMARY OF FOUR PATIENTS SUBJECTED TO PARTIAL MANDIBULAR  
RESECTION  
(Carcinoma of the Floor of Mouth)

Case number	1	2	3	4
Age	76	54	65	82
Stage of initial lesion	I	I	II	IV
Treatment of primary	R-S	S-R	R-S	R-S
Years primary controlled	1	.5	.5	
Stage at time of resection	IV	IV	III	IV
Resection years after onset	2	2	1	2
Tracheotomy	-	-	-	+
Segmental resection of mandible	+	+	+	+
Hemisection and disarticulation	-	-	-	-
Suprahyoid dissection	+	+	+	-
Supra-omohyoid dissection	-	-	-	-
Oral cutaneous fistula	+	+	-	-
Postoperative radiation	+	+	-	-
Postoperative death	-	-	-	+
Alive free of disease—(yr.)	.	2	.	.
Dead free of disease (yr.)	.	.	.	.
Alive with disease (yr.)	.	.	.7	.
Dead with disease (yr.)	1	.	.	.

hyoid neck dissection was performed for metastatic cervical carcinoma, without the control of the primary growth, which fails to meet one of the fundamental criteria of operability recommended by Duffy.<sup>23</sup> A number of teeth were extracted for pain in the mandible some time after the radiation therapy.<sup>24</sup> The patient refused surgical treatment for a Stage III lesion, and some months later accepted a tracheotomy which provided relief from pain up to the time of his death approximately twenty-six months after the onset of the disease. Owing to the malignant character of carcinoma of the floor of the mouth, prompt and effective initial therapy is a prime requisite, as any delay or inadequate therapy carries a grave responsibility.

#### MANDIBULAR RESECTION

The essential surgical considerations of partial mandibular resection, combined with dissection of the submandibular triangles, were fully described in the papers of Bartlett and Callander,<sup>25</sup> Blair and Brown,<sup>26</sup> Crile,<sup>27</sup> Hotchkiss,<sup>28</sup> Kennedy,<sup>29</sup> Padgett,<sup>30</sup> Polya,<sup>31</sup> Simmons,<sup>32</sup> Taylor and Nathanson,<sup>33</sup> Warren,<sup>34</sup> and others.

Fifty-seven patients with secondary carcinoma of the mandible were subjected to mandibular resection, with ten operative deaths (17 per cent). There were thirteen jaw resections for secondary carcinoma due to primary carcinoma of the lip, with three deaths; twelve operations for secondary carcinoma due to primary carcinoma of the buccal mucosa, with one death; twenty-eight operations for secondary carcinoma due to primary carcinoma of the lower gingiva, with five deaths; and four resections for secondary carcinoma due to carcinoma of the floor of the

mouth, with one death. The deaths were due to sepsis, pneumonia, and respiratory obstruction. The cause of one death was not clear from the record.

Seven cases presented an associated radionecrosis; and although presence of cancer was not substantiated by the histopathologic examination of four of them, it was thought that as a result of the usual practice of sectioning only a reasonable portion of the operative specimen of the mandible and contiguous structures the microscopic presence of cancer in the bone could easily have escaped detection, or could have been destroyed by the irradiation reaction.

Wangensteen has advocated in this clinic the use of tracheotomy in extensive resections of the mandible, as a means of controlling immediate postoperative mortality. In the last fifteen resections done by me, routine preliminary tracheotomy was performed, subsequently free of all complications and well tolerated by the patients. This procedure delayed the principal operation about five days, but it was found on several occasions to be a valuable part of the planned procedure, especially in those cases in which supporting structures of the base of the tongue had to be removed. In addition to providing a constant airway, it provides an opportunity for the anesthetist to use his equipment removed from the field of operation. General anesthesia was employed in these operations, and accomplished with intratracheal administration of oxygen and ether, except recently when pentothal sodium was used intravenously and the airway maintained through the tracheotomy tube.

The treatment of extensive carcinoma involving the mandible presents an opportunity to direct surgical procedures toward the treatment of the primary lesion and the lymph nodes metastases as a single procedure. The extent of the resection and of the dissection was generally planned to include one group of nodes beyond those involved. However, resection was performed for ten patients (Table VII) without dissection of the submandibular lymphatics. During the dissection, periodic microscopic examination of tissue to remain has been of assistance in those cases with fibrotic tissue reaction due to radiation therapy.

The often mentioned danger of any surgical intervention about the mouth and neck following heavy doses of radiation has been circumvented by means of two factors: extending the operation beyond the anatomic limits of fibrosis and avascularity, and careful postoperative management of the surgical wound.

The early employment of urea and sulfathiazole in various concentrations, directed by a power spray into the wound, reduced the postoperative pain and swelling, the amount and severity of the infection which was invariably present, and the characteristic foul odor of oral cavity wounds. The result of daily visits to the cleanup clinic<sup>35</sup> in the healing of wounds after the previous employment of considerable irradiation was particularly gratifying.

TABLE VII

ONE-STAGE MANDIBULAR RESECTION AND CERVICAL LYMPHATIC NODE DISSECTION  
EMPLOYED IN FIFTY-SEVEN CASES OF CARCINOMA OF THE MANDIBLE

SURGICAL PROCEDURE	LOCATION OF PRIMARY CARCINOMA									
	LIP		BUCCAL MUCOSA		GINGIVA		FLOOR OF MOUTH		TOTALS	
	STAGE III	STAGE IV*	STAGE III	STAGE IV*	STAGE III	STAGE IV*	STAGE III	STAGE IV*	STAGE III	STAGE IV*
Partial mandibular resection	2	2	2	—	1	2	—	1	5	5
Partial mandibular resection and suprahyoid dissection	1	1	1	1	5	4	2	1	9	7
Partial mandibular resection and supra-omohyoid dissection	—	—	—	—	1	1	—	—	1	1
Hemisection and disarticulation	—	—	—	—	1	3	—	—	1	3
Hemisection and disarticulation and suprahyoid dissection	—	4	2	4	2	3	—	—	4	11
Hemisection and disarticulation and supra-omohyoid dissection	1	2	2	—	3	2	—	—	6	4
Totals	4	9	7	5	13	15	2	2	26	31

\*Metastases confirmed by histologic examination.

Postoperatively an oral cutaneous fistula was present in twenty-nine patients. The plastic surgery procedures required for closure of the defect were performed by the plastic service after a prolonged period of observation failed to reveal any evidence of recurrence.

### RESULTS

An unselected series of seventy-one cases of secondary carcinoma of the mandible is subjected to analysis. The primary lesion was in thirty-four cases controlled for variable periods of time, although only eleven patients (17 per cent) remained free from disease or died of metastases without the local recurrence of the primary lesion.

TABLE VIII

SUMMARY OF SEVENTY-ONE CASES OF SECONDARY CARCINOMA OF THE MANDIBLE

Inoperable	7														Postoperative deaths	10
Refused operation	7														Survived operation	47
Resections	57														Indeterminate (untraced)	9
	6	1	2	3	4	5	6	7	8	9	14	16	17	TOTAL		
	MO. YR.	YR.	YR.	YR.	YR.	YR.	YR.	YR.	YR.	YR.	YR.	YR.	YR.			
Alive, free of disease	6	4	4	2	3	—	2	1	—	1	—	1	—	24		
Dead, free of disease	1	2	—	—	1	—	—	—	2	—	1	—	—	7		
Alive with the disease	—	3	—	—	—	—	—	—	—	—	—	—	1*	4		
Dead with the disease	2	7	3	—	—	—	—	—	—	—	—	—	—	12		
Alive free of disease	3 yr. 15 (6 indeterminate)														31.9%	
Alive free of disease	5 yr. 9 (8 indeterminate)														19.2%	
Alive free of disease	8 yr. 6 (8 indeterminate)														12.8%	

\*Recurrence in skin flap raised 15 years previously from the neck to close oral cutaneous fistula.



The results of fifty-seven jaw resections undertaken for advanced carcinoma involving the mandible, and frequently associated with regional metastases, are tabulated in Table VIII. The operative mortality of fifty-seven jaw resections was 17.5 per cent.

Preliminary tracheotomy as a routine procedure has improved recent mortality figures; there were no deaths in the last group of fifteen jaw resections.

Of forty-seven patients surviving operation, 31.9 per cent lived three years; 19.3 per cent lived free of disease five years, and 12.8 per cent lived free of disease for eight years.

# REFERENCES

1. Thoma, Kurt H.: Tumors of the Mouth and Jaws, Collective Review, Surg., Gynec. & Obst. 67: 522-545, 1938.
2. Ewing, James: Neoplastic Diseases, ed. 4, Philadelphia and London, 1940, W. B. Saunders Co., p. 62.
3. Thoma, Kurt H.: Clinical Pathology of the Jaws, Springfield and Baltimore, 1934, Charles C Thomas, Publisher, p. 608.
4. Geschickter, Charles F., and Copeland, Murry M.: Tumors of Bone, revised edition, New York, 1936, American Journal of Cancer, p. 559.
5. Ivy, Robert H.: Thyroid Tumor of the Mandible, Ann. Surg. 94: 437-440, 1931.
6. Burket, Lester W.: Jaw Metastases in Primary Mammary Carcinoma, Am. J. Orthodontics 27: 652-659, 1941.
7. Goldstein, Irving H., and Goldstein, M. C.: Jaw Metastases in Chondroblastic Osteogenic Sarcoma, Am. J. Orthodontics 29: 57-59, 1943.
8. Piazzola, Giorgio: Metastases of Malignant Tumors to the Jaws, Stomatol. ital. 19: 1050-1062, 1940.
9. Kronfeld, Rudolf, and Weinman, Joseph P.: Metastatic Adenocarcinoma in the Lower Jaw Bone, Arch. Path. 29: 683-690, 1940.
10. Stern, Leo, and Shepard, Alfred: Metastatic Carcinoma of the Mandible, J. Am. Dent. A. 23: 707-709, 1941.
11. Wangenstein, Owen H.: Cancer Clinic in a University Hospital, Surg., Gynec. & Obst. 64: 502-503, 1937.
12. Howes, W. E., and Bernstein, L.: Oral Carcinoma, Radiology 37: 468-475, 1941.
13. Beiswanger, R. H.: Carcinoma of the Cheek, Alveolar Process, Floor of the Mouth and Palate, Staff Meeting Bull. Hospitals of the Univ. Minn. 14: 225-252, 1943.
14. Malassez, L. C.: Role of the Paradental Debris, Arch. de physiol. norm. et path. 5: 1885.
15. Thoma, Kurt H.: Carcinoma of the Mandible, Am. J. Orthodontics 24: 995-999, 1938.
16. Buirge, Raymond E.: Carcinoma of the Large Intestine, Review of 416 Autopsy Records, Arch. Surg. 41: 801-818, 1941.
17. Smith, F. M.: Factors Causing Delay in Operative Therapy of Carcinoma, Surg., Gynec. & Obst. 60: 45-54, 1935.
18. Martin, Hayes E., and Sugarbaker, Everett L.: Cancer of the Floor of the Mouth, Surg., Gynec. & Obst. 71: 347-359, 1940.
19. Gettinger, Raymond: Biopsy in Oral Surgery, J. Am. Dent. A. 25: 451-467, 1938.
20. Darlington, Charles G.: "So-Called" Tumors of Special Interest to the Dentist, Dental Cosmos 65: 652-662, 1933.
21. Eggers, Carl: Cancer Surgery, The Value of Radical Operations for Cancer After the Lymphatic Drainage Area Has Become Involved, Ann. Surg. 106: 668-689, 1937.
22. Ochsner, A. J.: The Treatment of Cancer of the Jaw With the Actual Caustery, J. A. M. A. 81: 1487-1491, 1923.
23. Duffy, James J.: Treatment of Cervical Nodes in Intra-Oral Cancer, Surg., Gynec. & Obst. 71: 664-671, 1940.
24. Kanthak, Frank J.: Jaw Necrosis Irradiation, J. Am. Dent. A. 28: 1925-1929, 1941.
25. Bartlett, E. I.: Neck Dissection for Metastatic Carcinoma, Pack, G. T., and Livingston, E. M.: Treatment of Cancer and Allied Diseases, New York, 1940, Paul B. Hoeber, p. 608-621. Bartlett, E. I., and Callander, C. L.: Dissection of the Neck, Arch. Surg. 16: 1214-1231, 1928.

26. Blair, V. P., and Brown, J. B.: The Treatment of Cancerous or Potentially Cancerous Cervical Lymph Nodes, *Ann. Surg.* 98: 650-661, 1933.
27. Crile, G. W.: Excision of Cancer of the Head and Neck, *J. A. M. A.* 47: 1780-1786, 1906.
28. Hotchkiss, Lucius W.: A Method of Operation in Extensive Cancerous Growths of the Cheek Involving the Jaw, *Ann. Surg.* 48: 515-526, 1908.
29. Kennedy, R. H.: Epithelioma of the Lower Lip, *Ann. Surg.* 106: 577-583, 1937.
30. Padgett, Earl C.: *Surgical Diseases of the Mouth and Jaws*, Philadelphia and London, 1938, W. B. Saunders Co., p. 615.
31. Polya, Eugene: Technique of Operations for Carcinoma of the Buccal Mucous Membrane, *Surg., Gynec. & Obst.* 43: 343-354, 1928.
32. Simmons, C. C.: Cancer of the Mouth, *Surg., Gynec. & Obst.* 43: 377-382, 1926.
33. Taylor, G. W., and Nathanson, I. T.: *Lymph Node Metastases, Incidence and Surgical Treatment in Neoplastic Disease*, New York, 1942, Oxford University Press, p. 399.
34. Warren, J. Collins: Cancer of the Mouth and Tongue, *Ann. Surg.* 48: 481-514, 1908.
35. Buirge, Raymond E.: Unpublished data.

## JEJUNOSTOMY FOR DECOMPRESSION OF THE POSTOPERATIVE STOMACH

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DECOMPRESSION of the stomach segment following subtotal resections has been found desirable by many surgeons. The Levine or Jutte type of tube introduced through the nares preoperatively has often been left in place until secretions and food pass readily through the stoma. Some men have preferred the bidaily introduction of the nasal catheter to prevent dilatation of the stomach. Others have used intubation only to meet the need when it arises. All are agreed that convalescence is enhanced if nausea and vomiting can be avoided. Acute dilatation is a distressing complication and once it occurs, there is much delay in regaining normal tone in the stomach. The need for immediate and constant decompression has occurred so frequently in our experience that we have long used one method or another routinely. Usually, we have depended upon the inlying nasal catheter either on Wangenstein suction or simple gravity drainage. Although patients can be taught to bear with some fortitude the discomfort of the nasal tube, they all dislike it.

A few years ago, we published a report of a simple method of using a jejunostomy tube for feeding when faced with a malfunctioning stoma.<sup>1</sup> This technique has been used extensively in the past few years and the tube has often been placed in the jejunum at the time of the original operation. Patients in a poor nutritional state and those whose temperaments made intravenous feedings disagreeable have been benefited by jejunostomy feedings. In no instance have we met with serious complications from this procedure.

Numerous tubes have been devised to combine proximal decompression with jejunostomy feedings. Abbott and Rawson<sup>2</sup> advocated a double lumen tube introduced through the nares into the stomach before operation. The distal portion of the tube was introduced into the jejunum before the anastomosis was completed. This segment was used for postoperative feeding. That portion of the tube lying in the stomach segment was perforated so that suction could be applied and thus prevent dilatation.

Wangenstein<sup>3</sup> devised a forked catheter, one arm resting in the closed duodenal limb and one remaining in the stomach segment. He had been troubled by the temporary obstruction in the duodenal seg-

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ment and felt that decompression of this portion of the intestine was tremendously important. In our experience, the duodenal segment empties into the stomach freely enough through the anastomosis. We have been bothered, at times, by the failure of this irritating secretion to proceed into the jejunum.

Mersheimer<sup>4</sup> combined the Abbott-Rawson and the Wangenstein principles and devised a tube that decompressed the duodenum and the stomach and allowed the distal segment which was placed in the efferent limb of the jejunum to be used for either decompression or feeding. All of these tubes require manipulation through the partially made stoma. Although this type of contamination may often be justified, there has been considerable hesitation on the part of many surgeons to accept it.

Horsley<sup>5</sup> has used proximal decompression by gastrostomy in the Billroth I type of operation he prefers. A catheter is introduced through the anterior wall of the stomach and brought out through a small stab wound. This method appealed to us as ideal but is not feasible when radical subtotal gastrectomy is done, since the stomach remnant lies beneath the chest wall. This would necessitate either pulling down on the stomach segment in order to have the opening seal itself against the peritoneum when the catheter was removed, or allowing the tube to lie free for a distance between the stomach and the abdominal wall.

Bisgard<sup>6</sup> employed a similar gastrostomy catheter, extending it through the anastomosis into the efferent jejunal loop for feeding. Ravdin and associates<sup>7</sup> combined Horsley's and Bisgard's type of gastrostomy tube, using one segment for gastric decompression and the other for jejunal feedings.

In the fall of 1942, we were forced to operate for obstructing duodenal ulcer on a man who had three weeks previously been operated upon for ethmoiditis. We did not like the idea of an inlying nasal catheter and we were convinced that proximal decompression as well as early feeding would be desirable. Therefore, after a subtotal resection had been done, we introduced a No. 16 French double-eyed Bardex catheter through the jejunum and into the stomach segment. A second catheter, No. 16 French of the whistle-tip variety, was introduced a little further down in our customary manner for feeding. These were brought out through omentum and separate tiny stab wounds in the abdominal wall. Since then, we have used the proximal jejunostomy for decompression in ninety-seven patients. Many of them have had concomitant jejunostomies for feeding. In no instance has any complication arisen from these jejunostomies. Local sepsis has been inconsequential. The patients have been comfortable and no intestinal fistulas have occurred. There were four instances of lower lobe atelectasis in this group; there were no instances of pneumonia. So far, our follow-up studies revealed no complications from the jejunostomy sites.

Gravity drainage is used for three days, and then the tube is elevated to the level of the mouth. If, at the end of this time, there is a continued outpouring of secretion, further drainage is allowed. Occasionally, the tube is put on Wangensteen suction. If the amounts are

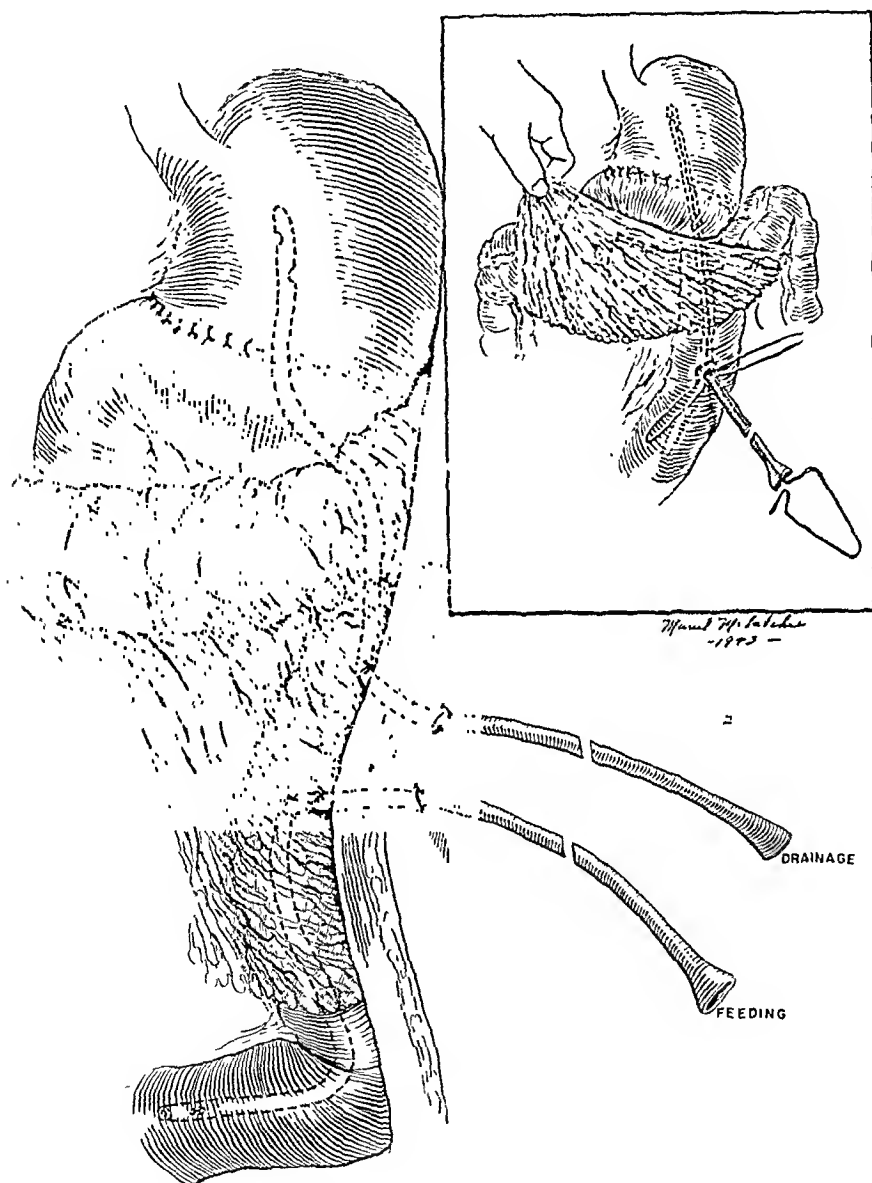


Fig. 1.

large and continue for a number of days, these secretions are added to the jejunostomy feedings. Usually the drainage is of small amount after the third day and then the tube is clamped off until it can be removed. The catgut purse-string suture deteriorates about the tenth day,

and if the tube is no longer needed, it can be withdrawn. In three instances, the catheter was not introduced far enough into the stomach segment and it dropped back into the jejunum. These patients required the use of the nasal catheter for a short period of time.

#### TECHNIQUE

After the anastomosis is completed, a site six to eight inches on the efferent loop of the jejunum is selected. A purse-string suture of 0 plain catgut is placed, through which the gut is perforated. A No. 16 French double-eyed Bardex catheter threaded on a lubricated stilet is then guided through the anastomosis to the center of the stomach remnant and the stilet withdrawn. The suture is tied and then the wall of the catheter is fixed at this point by the same suture, care being taken not to penetrate the lumen. A second purse-string suture of double 0 chromic catgut is then placed around the tube. A tiny stab wound is made in the left anterior axillary line well away from the laparotomy wound. A hemostat is passed through the stab wound, then through a convenient tab of omentum and the catheter is held firmly against the abdominal wall. It is fixed with a carefully placed silk suture to the skin. It is important not to penetrate the catheter at this point and not to obstruct its lumen by tying the suture too tightly.

If it is desirable to prepare for jejunostomy feedings, the second tube is placed about four inches below the first by a technique previously described.<sup>1</sup> A second tiny stab wound is made two inches below the first one to allow the feeding jejunostomy to be dressed separately from the drainage tube.

We have used this technique with the elimination of the inlying nasal tube following total gastrectomy for carcinoma, with equal satisfaction.

#### REFERENCES

1. Allen, A. W., and Welch, C. E.: Jejunostomy for the Relief of Malfunctioning Gastroenterostomy Stoma, *SURGERY* 9: 163-182, 1941.
2. Abbott, W. O., and Rawson, A. J.: Tube for Use in Postoperative Care of Gastroenterostomy Patients, *J. A. M. A.* 112: 2414, 1939.
3. Wangensteen, O. H.: Aseptic Resections in Gastrointestinal Tract With Special Reference to Resection of Stomach and Colon, *Surg., Gynec. & Obst.* 72: 257-281, 1941.
4. Mersheimer, W. L.: A Double Tube Method for Drainage and Feeding Following Gastric Resection or Gastroenterostomy, *SURGERY* 12: 563, 1942.
5. Horsley, J. Shelton: The Billroth I Type of Partial Gastrectomy, *South M. J.* 35: 456, 1942.
6. Bisgard, J. Dewey: Gastrostomy-Jejunal Intubation, *Surg., Gynec. & Obst.* 74: 239, 1942.
7. Ravdin, I. S., Rayster, H. P., Riegel, Cecilia, and Rhoads, J. E.: Surgical Care of Patients With Gastric Cancer Before and After Operation, *Arch. Surg.* 46: 871, 1943.

## PERFORATION OF POSTOPERATIVE JEJUNAL ULCERS

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THE problem of postoperative jejunal ulcer is one of such absorbing interest as to engage the attention of the surgeon and gastroenterologist alike. Its importance is evidenced by the fact that the frequency and severity of this complication is almost solely responsible for the current disrepute of the procedure of gastroenterostomy as a means of treatment of duodenal ulcer. That the same pathologic process may ultimately bring disrespect to the operation of subtotal gastrectomy is not beyond the realm of conjecture. In fact, recent reports make it increasingly evident that the substitution of partial or subtotal gastrectomy for simple gastroenterostomy will not, in itself, entirely eliminate this distressing consequence of gastrojejunal anastomosis. At the same time it is generally conceded that gastrectomy is less likely to be followed by jejunal ulcer than is gastroenterostomy.

By far the most dramatic, albeit the least common, complication of jejunal ulcer is free perforation into the peritoneal cavity. The first recorded case of this accident was described by Braun,<sup>1</sup> in 1899. Subsequently, summary reports appeared by Paterson,<sup>2</sup> in 1909, by Wright<sup>3</sup> in 1919, and Massie<sup>4</sup> in 1924. Ten years later, Singer and Meyer,<sup>5</sup> recorded 100 perforations which had occurred in 86 patients. Wilkinson<sup>6</sup> added two more in 1935. Braeci,<sup>7</sup> in 1938, found approximately 200 recorded instances of perforated jejunal ulcer in the literature. To recent reports by Lewishon,<sup>8</sup> Grossman,<sup>9</sup> Law,<sup>10</sup> Wells,<sup>11</sup> Colp,<sup>12</sup> and Marshall and Devine,<sup>13</sup> totaling thirteen cases, we present four added examples of the condition, two of which occurred in the same patient. It is difficult to collect all of the recorded cases since many of them are reported as isolated case reports in communications primarily concerned with the broader aspects of peptic ulceration. Nevertheless, it may be assumed that the free perforation of a jejunal ulcer is a relatively rare intra-abdominal accident.

Singer and Meyer<sup>5</sup> emphasize the predisposition of patients who have experienced rupture of a jejunal ulcer to perforation in general. A surprisingly large percentage (66 per cent in one series recited by Singer and Meyer) of patients exhibiting this syndrome will have had a previous perforation of a gastroduodenal ulcer. Furthermore, the patient who experiences a perforated jejunal ulcer will frequently display a distinct proclivity toward recurrent perforation. Multiple recurrences have been reported by Robinson,<sup>14</sup> Brandtner and Tönnis,<sup>15</sup>

Nixon and Lowry,<sup>16</sup> Reiss,<sup>17</sup> Davenport,<sup>18</sup> Henry,<sup>19</sup> and Wells.<sup>11</sup> One of our patients (R. F.) had a perforated duodenal ulcer, followed by two jejunal perforations, the latter two occurring only six months apart.

The symptomatology of perforated jejunal ulcer is essentially the same as that of gastroduodenal rupture, with minor exceptions. The initial pain is usually located to the left of the midline and just above the umbilicus in jejunal perforation, whereas it is higher in the epigastrium and frequently to the right of the midline in gastroduodenal rupture.

Location of these ulcers is interesting and significant. Although commonly referred to as marginal ulcer, this is a misnomer for they occur infrequently at the stoma and only rarely involve the gastric mucosa. The use of the term jejunal ulcer is therefore preferable since it is more descriptive of the pathologic process. The lesions are found entirely within the jejunum, either opposite the anastomosis or in the efferent loop, several centimeters distal to the stoma. The afferent loop is relatively immune to ulceration. When the ulceration involves the gastric mucosa, it is believed to have originated in the jejunum, and to have spread secondarily to the stomach. These areas of localization are in accord with the well-established sensitivity of jejunal mucosa to gastric secretions.

The pathology and treatment of perforated jejunal ulcers are obviously the same as those for gastroduodenal rupture.

**CASE 1.**—Perforation of jejunal ulcer following partial gastrectomy, operative closure with recovery, recurrent perforation of jejunal ulcer, operative closure with recovery, subsequent resection of jejunal ulcer.

R. F., (Hospital No. 217074), a white man, 37 years of age, was admitted to the Henry Ford Hospital on March 9, 1938, with a history of chronic, postprandial epigastric distress, which was associated with nausea and vomiting and relieved by milk and alkali. A definite diagnosis of active duodenal ulcer was made and medical management was instituted. The patient, a chronic continuous alcoholic with well-established psychoneurotic tendencies, failed to observe the prescribed regimen and was readmitted to the hospital for intensive therapy several times within the year. In April, 1939, he experienced a perforation of the duodenal ulcer which was closed elsewhere. Recovery, which was uneventful, was followed by an early recurrence of ulcer distress. Consequently, a partial gastrectomy was performed Nov. 1, 1940. Approximately four-fifths of the stomach was removed. A posterior gastroenterostomy was employed, the anastomosis being 20 cm. distal to the ligament of Treitz. Because of the size and acuteness of the ulcer it was deemed inadvisable to excise it, and therefore the Finsterer exclusion procedure was employed. The patient enjoyed considerable relief for several months, but later suffered a recurrence of chronic pain in the epigastrium. The suspicion of a marginal ulcer was entertained, but could not be verified by x-ray or gastroscopic examination. July 27, 1942, the patient was seized with a sudden sharp pain in the left upper quadrant of the abdomen, followed within a few hours by nausea and vomiting. On admission, the temperature, pulse, and respirations were essentially normal, the white blood count was 17,500, with 86 per cent polymorphonuclears. Abdominal examination revealed generalized tenderness, rigidity, and rebound phenomenon. A diagnosis of ruptured peptic ulcer was made and operation advised.



The abdomen was opened through an upper midline incision, under ampere-arc anesthesia, revealing the unmistakable evidence of perforation of a hollow viscus. By following the streaks of fibrin and free peritoneal fluid which appeared to flow from beneath the greater omentum, a 1 mm. perforation was found in the efferent loop of the jejunum about 7.0 cm. distal to the gastrojejunal anastomosis. A large indurated mass surrounded the perforation and extended into the mesentery of the jejunum. The perforation was closed with three interrupted, through-and-through, catgut sutures. A free omental graft was used to cover the perforation and the previously placed sutures were tied over the graft to secure it. One cigarette drain was inserted along the left colic gutter and another was placed into the pelvis and allowed to emerge through a suprapubic stab wound. Five grams of powdered sulfanilamide were sprinkled into the peritoneal cavity and the incision was closed with silk. The patient developed a high intestinal fistula, presumably at the site of the perforation, on the fifth postoperative day. Because of the presence of a definite hypoproteinemia, 1,000 c.c. of a 5 per cent solution of amino acids were administered daily, with rapid healing of the fistula. The patient was discharged Aug. 21, 1942.

Feb. 28, 1943, the patient was readmitted to the emergency room with the obvious signs of recurrent perforation. Through a midline incision, under spinal anesthesia, the abdomen was entered and the site of the previous perforation of the jejunum was inspected. Another perforation, apparently in the same ulcer, was found. It was repaired with a free omental graft; the abdomen was drained and closed, as before. Convalescence was devoid of untoward incident.

The patient returned to the hospital on April 28, 1943, when a lysis of the gastroenterostomy with resection of about 14 cm. of jejunum, including the ulcer, was performed. Recovery was uneventful.

**CASE 2.**—Perforation of duodenal ulcer, closure and gastroenterostomy; perforated jejunal ulcer; massive hemorrhage from jejunal ulcer; partial gastrectomy.

W. II. (Hospital No. 74523) was a 52-year-old white man, who had been treated for duodenal ulcer since 1926. Jan. 3, 1940, simple closure of a perforated pyloric ulcer was performed in the Henry Ford Hospital. The patient experienced post-operative pyloric stenosis which was relieved by a posterior gastroenterostomy, Feb. 29, 1940. The subsequent course was satisfactory until Nov. 26, 1942, when he was admitted to the emergency room three hours after the onset of sudden, severe, epigastric pain, which rapidly became generalized. Physical examination revealed extreme tenderness and marked rigidity of the entire abdomen. White blood count was 12,800 with 80 per cent polymorphonuclears. Flat plate of the abdomen disclosed a pneumoperitoneum.

The abdomen was opened under spinal anesthesia, revealing some free fluid and streaks of fibrin. The stomach and duodenum appeared normal. Upon reflecting the omentum and transverse colon cephalad, a 4 mm. perforation was observed in the jejunum opposite the anastomosis. A wide area of induration surrounded the perforation. The opening was closed with three through-and-through chromic catgut sutures, tied over a free omental graft. The pelvis and left pericolic gutter were drained and the incision was closed with interrupted silk sutures. Convalescence was uneventful and the patient was discharged Dec. 12, 1942.

He was readmitted March 3, 1943, with a massive hemorrhage, presumably from the jejunal ulcer. He was treated conservatively and, after a hectic course, improved sufficiently to permit his discharge from the hospital March 27, 1943.

April 23, 1943, a subtotal gastrectomy, with resection of approximately 14 cm. of jejunum, was performed. The ulcer was healed, but considerable scarring was present at the site of the previous perforation. Between three-fourths and four-fifths of the stomach was removed and a posterior gastroenterostomy was performed,

the anastomosis being approximately 19 cm. distal to the ligament of Treitz. A Hofmeister-Finsterer technique was employed. November, 1943, the patient was asymptomatic.

### CASE 3.—Perforation of jejunal ulcer following gastroenterostomy.

E. S. (Hospital No. 388058), a white man, 37 years of age, was admitted to the Henry Ford Hospital, May 24, 1943. He had been treated periodically for duodenal ulcer since 1927. During the three-year interval between 1936 and 1939 he had suffered three attacks of massive hemorrhage from this ulcer. Jan. 19, 1939, an anterior gastroenterostomy with enteroenterostomy had been performed elsewhere. The patient had received considerable relief from his symptoms following the operation until the day of admission when he was suddenly seized with severe pain in the left upper quadrant of the abdomen, which came on while he was asleep, approximately three hours before admission. The pain was constant and excruciating. He had received morphine sulfate, gr.  $\frac{1}{4}$ , one hour before his arrival in the emergency room, but this had not relieved the pain. Examination revealed the temperature, pulse, and respirations within normal limits. The abdomen was rigid and exquisitely tender. The white blood count was 30,000, with 99 per cent polymorphonuclears. X-ray plates of the abdomen showed free air beneath the diaphragm.

The abdomen was opened through a midline incision, under spinal anesthesia. Much free fluid, fibrin, and air were present in the abdominal cavity. The stomach and duodenum appeared normal. There was a perforation, about 5 mm. in diameter, in the jejunum opposite the anastomosis. The perforation was closed with interrupted chromic catgut sutures, tied over a free omental graft, after 5 Gm. of sulfanilamide had been dusted into the peritoneal cavity. The pelvis and left colic gutter were drained and the incision was closed with silk. The postoperative course was uneventful, and the patient was discharged June 7, 1943.

### SUMMARY

1. Four examples of perforated jejunal ulcer are presented.
2. The term jejunal ulcer is more descriptive of the lesion than is the designation marginal or stomach ulcer.
3. Jejunal ulcers tend to occur, and to perforate, in patients who have had previous gastroduodenal perforations.

### REFERENCES

1. Braun, H.: Demonstration eines Präparates einer 11 Monate nach der Ausführung der Gastro-Enterostomie entstandenen Perforation des Jejunum, *Verhandl. d. deutsch. Gesellsch. f. Chir.* 28 (2): 94, 1899.
2. Paterson, H.: Jejunal and Gastrojejunal Ulcers Following Gastrojejunostomy, *Proc. Roy Soc. Med.* 2: 238, 1909; *Ann. Surg.* 50: 367, 1909.
3. Wright, G.: Secondary Jejunal and Gastric-jejunal ulceration, *Brit. J. Surg.* 8: 390, 1919.
4. Massie, G.: Perforated Jejunal Ulcer, *Guy's Hosp. Rep.* 74: 70, 1924.
5. Singer, Harry A., and Meyer, Karl, A.: Perforation of Jejunal Ulcer Into Free Abdominal Cavity, *Arch. Surg.* 29: 248, 1934.
6. Wilkinson, B. W.: Free Perforation of Jejunal Ulcers, *Am. J. Surg.* 29: 120-121, 1935.
7. Bracci, U.: Perforazione in peritoneo libero di ulcera peptica insorta dopo resezione, *Arch. ed atti d. Soc. ital. di chir* 44: 994-1002, 1938.
8. Lewishon, R.: Case Report New York Surgical Society, *Ann. Surg.* 100: 1027-1031, 1934.
9. Grossman, A.: Postoperative Jejunal Ulcer, *Ann. Surg.* 108: 105-123, 1938.
10. Law, W. A.: Perforated Jejunal Ulcer Following Partial Gastrectomy, *Brit. M. J.* 1: 844-846, 1940.

11. Wells, C.: Perforated Jejunal Ulcer After Gastrectomy, *Brit. M. J.* 1: 953, 1940.
12. Colp, R.: Surgical Problems in the Treatment of Gastrojejunal Ulceration, *Ann. Surg.* 114: 543-569, 1941.
13. Marshall, S. F., and Devine, J. W., Jr.: Gastro-jejunal ulcer, *S. Clin. North America* 21: 743-761, 1941.
14. Robinson, V. P.: A Case of Partial Gastrectomy for Pyloric Ulcer, Followed by Two Jejunal Ulcers Perforating at Intervals of Six Months, *Lancet* 703, 1928.
15. Brandtner, C. E., and Tönnis, W.: Beitrag zur Häufigkeit und Behandlung des Ulcus pepticum jejunum nach Gastro-enterostomie wegen perforiertem Magen und Duodenalulcus, *Deutsche Ztschr. f. Chir.* 236: 93, 1932.
16. Nixon, P. I., and Lowry, S. T.: Multiple Consecutive Perforated Gastrojejunal Ulcers, With Report of a Case, *M. J. & Rec.* 128: 584, 1928.
17. Reiss, P.: Zur Perforationsneigung des ulcers Pepticum, *Zentralbl. f. Chir.* 52: 2818, 1925.
18. Davenport, G. L.: Five Operations in Twelve Years for Perforation, *J. A. M. A.* 97: 99, 1931.
19. Henry, C. K. P.: Recurrent Gastric Perforation, *Surg., Gynec. & Obst.* 32: 542, 1921.

## A NEW PORTABLE SUCTION APPARATUS FOR USE WITH THE MILLER-ABBOTT TUBE

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**S**UCTION decompression of the intestinal tract by means of the Miller-Abbott principle has been firmly established as an important therapeutic procedure in distention due to paralytic or mechanical obstruction. Various types of suction have been devised which are satisfactory when the short gastroduodenal tube is utilized, but often considerable difficulty is encountered in securing constant suction of adequate degree when these devices are applied to a long tube. Paine,<sup>1</sup> in an extensive analysis of the factors operative in the use of suction for relief of distention, found a negative pressure produced by a column of water 2 feet 6 inches (56 mm. Hg) was satisfactory in most cases when a single lumen tube was used. This degree of suction is adequately delivered by the Wangenstein two-bottle apparatus. The effective negative pressure in this system is dependent upon the vertical distance from the tip of the tube in the gastrointestinal tract to the lower end of the siphon tube or the level of the water in the lower bottle if this end is submerged. Thus, the pressure will vary with the height of the bed, position of the patient, and location of the lower bottle. Abbott<sup>2</sup> has recently indicated that an effective negative pressure equivalent to 5 feet of water (112 mm. Hg) is required to secure adequate siphonage through the Miller-Abbott tube. This degree of suction can be produced by the three-bottle system. The variables inherent in the two-bottle system and the technical difficulties of operating the three-bottle system are minimized in the apparatus we will describe, which permits direct regulation of the degree of suction by the operator.

Our apparatus (Fig. 1) is a simple suction pump which can be cheaply assembled and will produce any desired degree of suction within safe limits. While we have seen no previous descriptions of a similar apparatus, its simplicity suggests that the principle has been used before this time. The pump can be operated by the patient (Fig. 2) in most instances—it cannot be reversed because there is only a single connection, and the degree of negative pressure in the unit does not depend on its location relative to the patient. It is a portable unit which may be carried to the bedside and suction instituted without delay. All parts liable to breakage are easily replaceable by equipment on hand in any hospital.

The apparatus (Fig. 3) consists of a single cylinder tire pump in which the leather piston is reversed so that suction results when the plunger is pulled upward. A tire valve stem and core, from which a portion of the spring is cut away, is connected between the pump and the vacuum bottle and prevents any possibility of producing pressure in the vacuum



Fig 1—Apparatus attached to Miller-Abbott tube

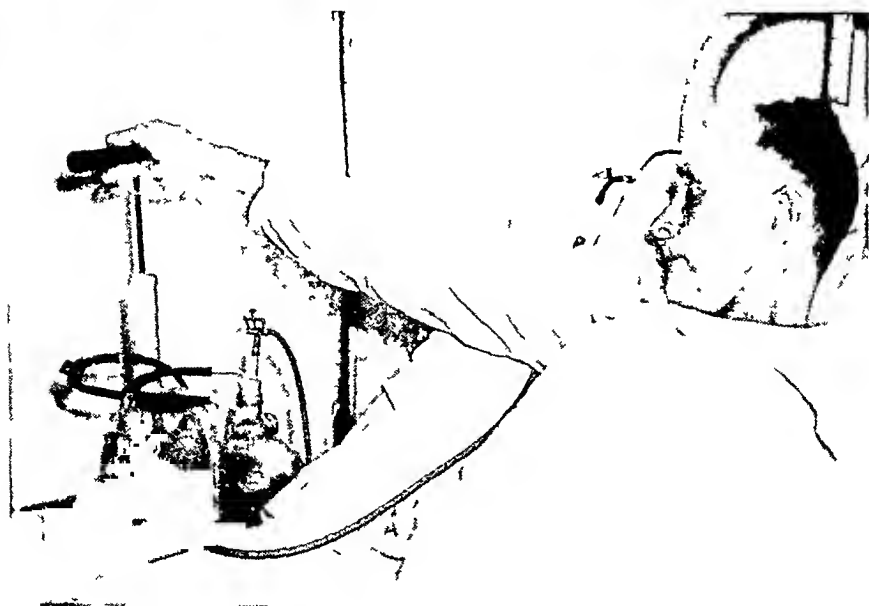


Fig 2—Patient operating suction pump

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of the tendency for the valve to leak. A second screw clamp is placed on the tubing coming to the reservoir bottle which is closed when the connection with the inlying tube is broken. In order to produce suction in the system the first screw clamp described is opened, the second one is closed, and the pump is operated. When the desired vacuum has been obtained the first clamp is closed and the second is opened to allow the suction to become effective.

During the past eight months we have utilized the apparatus in a number of cases of intestinal obstruction. In each instance the results have been gratifying to the patient, nurses, and attending physicians. Patients have remarked at the ease of operation and at no time has there been evidence of harm from the degree of suction utilized. This has been verified at autopsy by examination of the intestine. Nurses have been pleased with the simplicity of the apparatus and the infrequent attention which it requires. The only difficulties encountered were those related to leakage at the metal connector of the Miller-Abbott tube, which, however, will render any type of suction ineffective. Physicians who have utilized the apparatus have been impressed by the large quantities of fluid and gas which are removed within short periods of time and the consequent rapid passage of the tube through the small intestine.

Ordinarily when suction is effective in withdrawing quantities of fluid the plunger may have to be manipulated every two or three hours. However, after the bowel content has been largely removed, the pressure will be maintained for longer periods of time. The range of negative pressure which we have found to be most practical is between 45 and 90 mm. Hg. Between these levels approximately 500 c.c. of fluid will be removed. The presence of gas in the aspirated material will appreciably decrease this amount. In some instances it is unnecessary to have this degree of suction maintained and it is advisable to regulate this according to the amount of material coming through the tube.

Solid particles in the intestinal contents frequently cause blockage of the tube when the ordinary siphon drainage is used. Although this may occur when the present apparatus is in place, we have rarely observed any tendency for the tube to become obstructed nor has periodic irrigation of the tube been necessary.

It is possible that this type of portable apparatus may have wide applicability where low pressure suction in an airtight system is demanded.

An itemized list of materials required to assemble the apparatus which cost us \$5.50 follows:

- 1 single cylinder tire pump
- 1 carrying box
- 2 one-gallon jugs
- 1 tire valve stem and core (Schrader with outside spring)  
or one-way ball valve
- 1 three-way tube connector

- 1 6 inch test tube
- 2½ feet 6 mm. glass tubing
- 1½ feet rubber pressure tubing
- 2 No. 6 two-hole rubber stoppers
- 2 screw clamps
- 3 c.c. metallic mercury

#### SUMMARY

A simple, easily constructed, portable suction device is described which depends upon the fact that a tire pump will provide suction when the plunger is reversed.

The apparatus is designed primarily for use with the Miller-Abbott tube. Experiences with the suction device have demonstrated its effectiveness and simplicity of operation. Frequently the patient himself can attend almost entirely to its operation.

It is suggested that this principle may be utilized in other situations where continuous suction on an airtight compartment is desired.

#### REFERENCES

1. Paine, J. R.: The Hydrodynamics of the Relief of Distention in the Gastro-Intestinal Tract by Suction Applied to Inlying Catheters, *Arch. Surg.* 33: 995-1020, 1936.
2. Abbott, W. O.: The Use of the Miller-Abbott Tube in the Diagnosis and Treatment of Disorders of the Gastro-Intestinal Tract. *Advances in Internal Medicine*, New York, 1942, Interscience Publishers, Inc.



## MULTIPLE PRIMARY CARCINOMAS OF THE GASTROINTESTINAL TRACT

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TO THE pathologist or surgeon very experienced in the handling of cancer material the occurrence of multiple primary carcinomas in a patient is not a rare experience. A review of the literature reveals many single case reports and series of cases. Nevertheless, the average general surgeon or internist will encounter this condition only on infrequent occasions. Such an individual, even if reasonably well informed, may not even be aware of the existence of this problem. Immediately, important questions arise. Is this a chance phenomenon? What is the correct treatment and prognosis? How great is the incidence of this lesion? Will some knowledge of the answers influence one's future approach to carcinoma cases, especially those of the gastrointestinal tract? It is with such considerations in mind that this report is submitted.

We are presenting three cases; one surgical and two found at the autopsy table. The first case also has the added interest of having presented a difficult and intriguing diagnostic problem. It stresses the nature of right colon neoplasm symptoms, emphasizing the lack of local intestinal phenomena until late in the disease, and the general character of the early symptoms.

### CASE REPORTS

CASE 1.—C. C., a white woman 33 years of age, was admitted to the medical service of the Coney Island Hospital, Sept. 9, 1943. The chief complaints were marked weakness, anorexia, and continuous fever, with the temperature ranging daily from 99 to 101° F. since January, 1943.

Fifteen years prior to admission the patient had rheumatism which necessitated bed rest for one month. Two years later she noticed breathlessness on walking and occasional swelling of the ankles and legs. In the two years before admission she was subject to frequent colds and noticed occasional "heart palpitations." Six months prior to admission she was hospitalized at another institution for a month and treated for anemia. At this time there was an attack of diarrhea which lasted one week. Following her hospital discharge in January, 1943, she became progressively weaker, lost weight, and was confined to bed most of the time. In August, 1943, she had another episode of diarrhea which lasted two weeks and subsided spontaneously.

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Physical examination revealed a well-developed white woman markedly pale. The heart was enlarged to the left side. In the precordium there was a short systolic and long diastolic murmur best heard in the third left interspace. There was a short rough systolic blow at the aortic area. Abdominal findings and rectal examination were essentially negative. The working diagnosis was subacute bacterial endocarditis. Blood pressure was 164/66. Laboratory data: hemoglobin, 34 per cent; red blood cells, 2,830,000; white blood cells, 3,200; rods, 2 per cent; segmented forms, 71 per cent; lymphocytes, 27 per cent; blood platelets, 220,000. Blood culture was negative. Electrocardiogram showed marked left ventricular preponderance. Chest x-ray revealed cardiac enlargement, left ventricular. Proctoscopy was negative except for pallor of mucous membranes. Blood agglutination tests for typhoid,

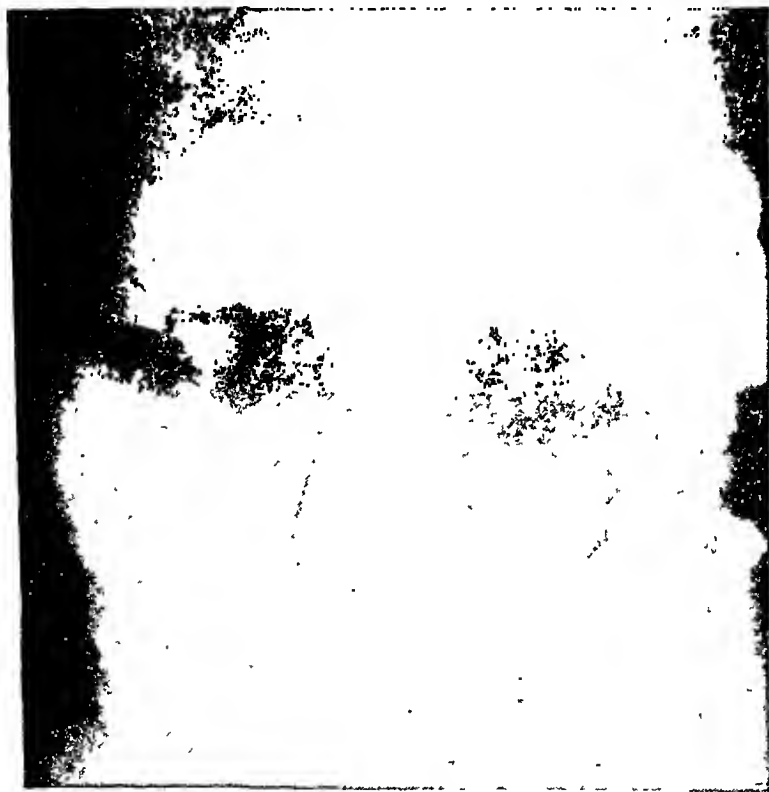


Fig. 1 (Case 1).—Barium enema reveals filling defects in transverse and ascending colon. Note colon redundancy at splenic flexure area.

paratyphoid A and B, *Proteus* OX19, and *Brucella abortus* were negative. Stools contained no ova or parasites. Blood sugar was 107 mg. per 100 c.c. and blood urea nitrogen, 10 mg. per 100 c.c. Bone marrow examination revealed no significant variations from the normal. Urine tests were negative. Colon x-rays (Fig. 1), on Sept. 17, 1943, revealed the rectum and rectosigmoid displaced to the left. There was a partial obstruction in the proximal transverse colon with evidence of narrowing of the gut in this region. There was also a defect in the midascending colon. The cecum and terminal ileum were normal. The diagnosis was multiple tumors of the proximal colon.

The patient was then transferred to the surgical service and prepared for operation by several transfusions. Operation was performed, Sept. 27, 1943, by one of us (W. S.). A pelvic mass consisting of a right ovarian cyst was removed. Resec-

tion of the terminal ileum, cecum, ascending colon, hepatic flexure, and the transverse colon at a distance about three inches distal to the distal neoplasm with end-to-side aseptic ileotransverse colostomy was accomplished. The entire tumor-bearing area was resected together with its mesentery. There was no evidence of gross metastasis either proximate or remote.



Fig. 2 (Case 1).—Postoperative barium enema. Note that the redundancy of the transverse colon at the left side is gone. The barium enters the small gut readily. There is a small pouch formation at the turned-in end of the transverse colon.

The patient made an uneventful recovery except for a mild wound infection. At time of discharge from the hospital three weeks postoperatively, she was afebrile and enjoyed a sense of well-being, hemoglobin and red blood cell count having risen to 75 per cent and 4,000,000 cells per c.mm. On this service we feel that the operative procedure here performed is the one of choice for neoplasms of the right colon.

*Pathologist's Report.*—

*Gross description:* The specimen was a loop of intestine consisting of a portion of ileum, ascending colon, and transverse colon measuring 45 cm. At 8 cm. from

the distal end of the transverse colon there was a cauliflower-like mass almost completely obstructing the lumen. It completely enveloped the entire circumference of the bowel and was 3 cm. in length (tumor A).



Fig. 3 (Case 1).—Gross specimen showing both carcinomas. Unfortunately, the photograph was made after fixation had caused shrinkage and distortion.

Thirteen centimeters proximal to this mass another neoplasm almost occluded the lumen of the colon. This was fungating and cauliflower-like, had a central contracted portion and some ulceration, and measured 6 by 3.5 cm. (tumor B).

*Microscopic Description:* In tumor A, the glands showed marked distortion and were lined by simple and multiple layers of columnar epithelium showing marked



Fig. 1.—Low-power field; tumor A.

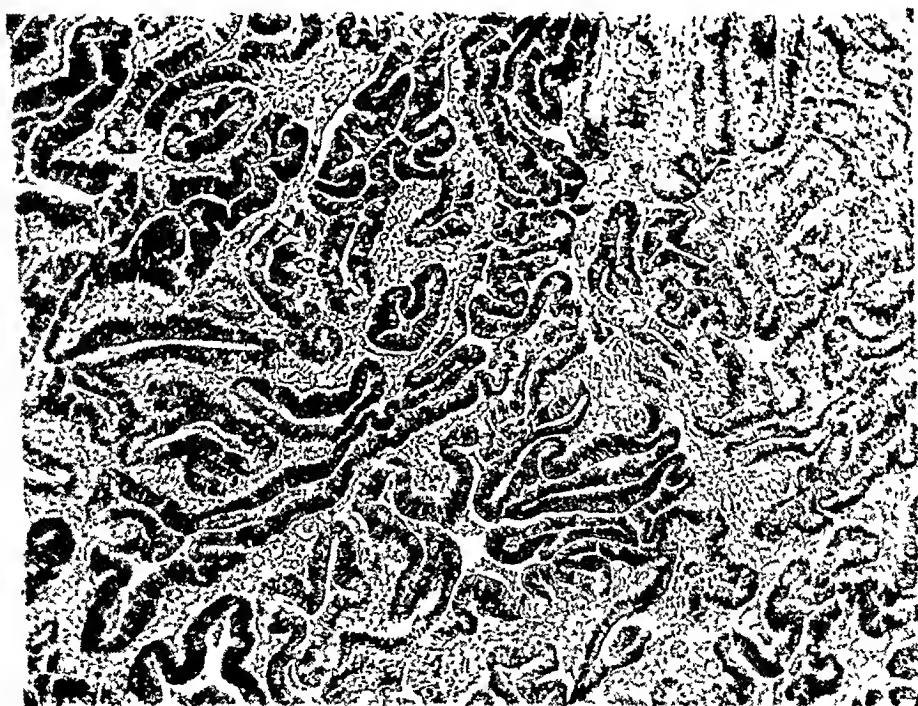


Fig. 5 —Low-power field; tumor B.



Fig. 6.—High-power field; tumor A.



Fig. 7.—High-power field; tumor B.

variation in size, shape, and staining characteristics. There was invasion through the basal membrane into the muscularis. Many large nucleoli with hyperchromatism were noted. There was a moderate desmoplastic reaction present.

In tumor B, sections showed similar structure to that noted in tumor A, with all the criteria of malignancy present. The stroma showed a diffuse polymorphonuclear round-cell infiltration. Also noted were large focal collections of lymphocytes with tendency toward follicle formation. Note that the tumor cells of one lesion resembled those of the other but were not identical; those of the second tumor were larger. There were no evidences of metastatic relationship. There was no metastatic involvement of lymph glands. The lymph sinuses and venous channels of the intervening mucosa of the colon showed no embolic malignant cells. The cells in each case apparently arose from their individual parent mucosal cell.

CASE 2.—S. W., a white man, aged 73 years, was admitted to the Conoy Island Hospital because of obstipation and distension of one week's duration. Three weeks prior to admission he noticed alternating diarrhea and constipation. The abdomen was markedly distended and rigid. There was a suggestion of an epigastric mass. While in the hospital the patient complained of substernal pain on ingestion of liquid or solid food no matter how small the amount. After two weeks he became comatose and died.

*Laboratory Data.*—Electrocardiogram revealed considerable myocardial damage. Blood count, urinalysis, blood sugar, and liver function tests were within normal limits. A flat plato of the abdomen was suggestive of an upper abdominal mass.

*Autopsy Findings.*—The liver was tremendously enlarged and was the site of widespread metastases. Numerous white nodular masses were in all the lobes. In the midportion of the esophagus there was a nodular mass 3 by 1 by 1 cm. On the lesser curvature of the stomach near the cardia there was a large ulcer 1.5 cm. in diameter. The edges were irregular and heaped. The wall was resistant to cutting. The gastrointestinal tract was otherwise negative. Microscopic examination of the esophageal mass showed diffuse squamous-cell infiltration into the muscularis with the usual criteria of malignancy. Microscopic examination of the stomach ulcer revealed the findings of adenocarcinoma. The metastatic lesions in the liver were similar to that of the stomach.

*Diagnosis:* (1) Squamous-cell carcinoma of esophagus; (2) adenocarcinoma of stomach with liver metastases.

CASE 3.—E. M., a white woman, aged 78 years, was admitted for hematemesis and abdominal pain of recent duration. No history of previous gastrointestinal disturbance was present. A mass about the size of a fist was palpable in the epigastrium. Pressure on this mass caused regurgitation of bright red blood. In spite of numerous transfusions and other supportive therapy, death ensued six days later. The pertinent findings at autopsy were as follows: An irregular punched out ulcer, 5 by 3 cm., was present on the posterior esophageal wall 7 cm. proximal to the cardia. The edges were sharply undermined and the base trabeculated. No regional adenopathy was present. In the prepyloric area of the stomach there was a large shallow ulcer 7 by 6 cm. on the anterior wall. The ulcer margins were heaped up. In the ulcer base an open-mouthed small vessel was present. Microscopic examination of the esophageal lesion revealed marked cellular activity with invasion of the muscularis by malignant cells showing variations in size, shape, and staining qualities. The stomach lesion had a necrotic base beneath which were confluent groups of larger cells with vesicular nuclei with prominent deeply staining basophilic nucleoli. These cells were arranged haphazardly and were found throughout all the layers of the stomach wall. No evidence of metastasis from either lesion was found.

*Diagnosis:* (1) Adenocarcinoma of stomach; (2) adenocarcinoma of esophagus. Each tumor was independent of the other.

### DISCUSSION

In order to ascertain the incidence of multiple primary malignancies at the Coney Island Hospital, a general municipal hospital of about 300 beds, we reviewed our available figures. In the ten-year period (1934 to 1943 inclusive) 1,493 autopsies were done; of these, malignant disease was the prominent feature in 128 cases. In these 128 cases there were two cases of multiple primary malignant tumors involving the gastrointestinal tract and one involving the breast and gall bladder. In eight cases malignancy associated with a significant benign tumor in another organ was found. A review of the surgical specimens of ten years (1934 to 1943 inclusive) revealed 330 cases of malignant specimens. Of these, 110 involved the gastrointestinal tract. In one case there were two synchronous malignancies of the gastrointestinal tract. There was no history of previous malignant lesions in any of the surgical cases. Since there was no adequate provision made for follow-up study of these cases, the incidence of the future new neoplasms could not be determined.

The number of cases involved are too few for statistical study or conclusions. Nevertheless, in a ten-year period of reasonable surgical activity, only one case of multiple malignancies of the gastrointestinal tract was encountered, and in a ten-year autopsy experience, only two cases were found.

TABLE I  
MULTIPLE PRIMARY NEOPLASMS OF THE GASTROINTESTINAL TRACT\*

AUTHOR	YEAR	CASE
Fenger <sup>1</sup>	1888	1 case
Major <sup>2</sup>	1918	15 cases of multiple malignancies (collected from literature) in large series of multiple neoplasms (excluding mouth and pharynx)
Miller <sup>4</sup>	1924	5 cases
Bargen and Rankin <sup>6</sup>	1930	16 cases
Hanlon <sup>7</sup>	1931	2 cases in 18 cases of double malignancies in 710 cases of malignancy
Warren and Gates <sup>8</sup>	1932	59 cases (collected from literature) and 3 cases from own material (1,078 cases of malignancy)
Abel <sup>9</sup>	1933	2 cases from 131 cases of carcinoma of colon and rectum
Bugher <sup>11</sup>	1934	1 case in 30 cases of multiple malignancies in 983 malignancies
Cockkinis <sup>13</sup>	1934	4 cases in total of 54 carcinomas of colon and 29 cases from the literature
Brindly <sup>14</sup>	1938	8 cases from 306 cases of large intestinal carcinoma, 2.6 per cent incidence
Schweiger and Bargen <sup>16</sup>	1940	16 cases
Tullis <sup>17</sup>	1942	6 cases from 1,044 autopsies on malignant lesions

\*Reported in the literature. (An illustrative but not complete compilation.)



Tables I and II are compilations from the literature. Table I shows the incidence of multiple primary malignancies of the gastrointestinal tract, multiple malignant polyps being excluded. Table II gives a tabulation of the general incidence of multiple primary lesions as gathered from carcinoma cases.

TABLE II  
GENERAL INCIDENCE OF MULTIPLE PRIMARY NEOPLASMS\*

AUTHOR	YEAR	CASE
Major <sup>2</sup>	1918	485 cases of multiple carcinoma (from literature)
Owen, L. J. <sup>3</sup>	1921	143 cases in 3,000 cases of malignancy, 4.7% incidence
Orr, J. W. <sup>5</sup>	1930	8 cases in 1,016 cases of malignancy (autopsy), 0.78% incidence
Hamton <sup>7</sup>	1931	18 cases in 710 cases of malignancy, 2.5% incidence; 31 cases in a large group of clinical cases
Warren and Gates <sup>8</sup>	1932	277 cases in 20,738 cases of malignancy (European), 1.3% incidence 40 cases in 1,078 cases of malignancy (American), 3.7% incidence
Hurt and Broders <sup>10</sup>	1933	71 cases in 2,124 cases of malignancy, 3.3% incidence
Schreiner and Wehr <sup>12</sup>	1934	307 cases in 11,212 cases of malignancy, 2.7% incidence
Bugher <sup>11</sup>	1934	30 cases in 983 cases of malignancy, 3.1% incidence
Stalker et al. <sup>15</sup>	1939	113 cases in 2,500 cases of malignancy, 4.52% incidence

\*Reported in the literature. (Illustrative but not complete compilation.)

Warren and Gates,<sup>8</sup> Hurt and Broders,<sup>10</sup> and Bugher,<sup>11</sup> after careful statistical study, conclude that the incidence of multiplicity of primary lesions is greater than chance incidence. Ewing,<sup>18</sup> Hamton,<sup>7</sup> and Orr,<sup>5</sup> however, are of the opinion that multiplicity of tumors is coincidental.

Age per se was not considered the significant factor in the development of multiple lesions by Warren and Gates.<sup>8</sup> The age of the patients with multiple tumors was not essentially greater than those with a single neoplasm. Another factor, increased biologic susceptibility to neoplasm formation or some unknown environmental conditions favoring the same, must be considered.

The therapeutic approach in multiple primary carcinoma cases should be essentially the same as in single carcinoma cases. Care must be taken to avoid confusion with metastatic lesions. If treated promptly the outlook should be as favorable as for single carcinoma of the part involved except for the possible greater surgical risk and the theoretic increased possibility of metastasis since these may now come from more than one source.

The appearance of two synchronous independent gastrointestinal lesions will raise surgical problems depending largely on the parts involved. If the growths are in a segment of the intestine that can be treated as a unit, as in Case 1, or if both lesions are on the left side

not too far apart, the operation can be the same as for a single lesion. Radical resection with primary re-establishment of intestinal continuity for right side and transverse colon lesions, or descending and transverse colon lesions, can be readily accomplished. Low left sided lesions should be subjected to combined abdominal perineal resection and permanent colostomy. Obstructive resection will be applicable in some cases. In the event the carcinomas are widely separated, as for example a right colon and left colon lesion, then the operation can be broken down into stages, the more urgent operation being performed first to be followed at a suitable time by a second radical procedure for the other neoplasm. The problems of obstruction or other complications must be dealt with as ordinarily. Complementary cecostomy or colostomy should be used as needed. The possible combinations are of course numerous, but a radical surgical approach should be planned wherever feasible. The reappearance of a single tumor involving the gastrointestinal tract after removal of a carcinoma is not necessarily indicative of recurrence. The possibility of a second primary neoplasm must be considered and radical surgery again employed if this is the case. It is also wise in dealing with a neoplasm of the intestinal tract to exclude multiplicity, since this has an appreciable, even if small, occurrence.

#### SUMMARY

1. Three cases of multiple primary malignant lesions involving the gastrointestinal tract are presented.
2. Some figures illustrating the incidence of multiple primary malignancies are given.
3. The therapeutic implications are briefly mentioned.

#### REFERENCES

1. Fenger, Christian: Double Carcinoma of the Colon, *J. A. M. A.* 11: 606-607, 1888.
2. Major, R. H.: Multiple Primary Malignant Tumors, *Johns Hopkins Hosp. Bull.* 29: 223-231, 1918.
3. Owen, L. J.: Multiple Malignant Neoplasms, *J. A. M. A.* 76: 1329, 1921.
4. Miller, R. T., Jr.: Multiple Primary Malignant Foci in Cancer of the Colon, *Ann. Surg.* 80: 456, 1924.
5. Orr, J. W.: Multiple Malignant Neoplasms, *J. Path. & Bact.* 33: 283-290, 1930.
6. Bargen, A. J., and Rankin, F. W.: Multiple Carcinomata of the Large Intestine, *Ann. Surg.* 91: 583, 1930.
7. Hanlon, F. R.: Multiple Primary Carcinoma, *Am. J. Cancer* 15: 2001-2012, 1931.
8. Warren, S., and Gates, O.: Multiple Primary Malignant Tumors, a Survey of the Literature and a Statistical Study, *Am. J. Cancer* 16: 1358-1414, 1932.
9. Abel, Irvin: Cancer of the Colon, *South M. J.* 26: 64, 1933.
10. Hurt, H. H., and Broders, A. C.: Multiple Primary Malignant Neoplasms, *J. Lab. & Clin. Med.* 18: 765-777, 1933.
11. Bugher, J. C.: The Probability of the Chance Occurrence of Multiple Malignant Tumors, *Am. J. Cancer* 21: 809, 1934.
12. Schreiner, B. F., and Wehr, W. H.: Multiple Primary Cancer as Observed at the State Institute for the Study of Malignant Disease, *Am. J. Cancer* 20: 418-424, 1934.

13. Cockkuijs, A. J.: Multiple Cancer of Colon With Four Original Cases, *Brit. J. Surg.* 21: 570, 1934.
14. Brindly, G. V.: Multiple Primary Malignancies of the Large Intestine, *South. M. J.* 31: 355, 1938.
15. Stalker, L. K., Phillips, R. B., and Pemberton, J. de J.: Multiple Primary Malignant Lesions, *Surg., Gynec. & Obst.* 68: 595-602, 1939.
16. Schweiger, L. R., and Bargon, J. A.: Primary Malignant Lesions of Large Bowel, *Arch. Int. Med.* 66: 1331-1340, 1940.
17. Tullis, J. L.: Multiple Primary Malignant Lesions, *J. Lab. & Clin. Med.* 27: 588-594, 1942.
18. Ewing, J.: *Neoplastic Diseases*, ed. 3, Philadelphia, 1928, W. B. Saunders Company, p. 37.
19. Gaudiu, H.: Multiple Primary Malignant Tumors, *New Zealand M. J.* 40: 367, 374, 1941.

## BILATERAL OOPHORECTOMY WITH RADICAL OPERATION FOR CANCER OF THE BREAST

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THAT the prognosis for cure of carcinoma of the breast is worse in young women when ovarian function is most active has been rather generally accepted. Thus, Ewing<sup>1</sup> says: "Before 30 years of age mammary cancer is extremely fatal, so that some surgeons prefer not to operate during this period. Schwartzoff reports 15 such cases, all rapidly fatal in spite of early operation." Taylor<sup>2</sup> writes: "There is a growing body of evidence, and rather general belief, that carcinoma of the breast in young women is more malignant and less curable than in older women." Sittenfield<sup>3</sup> states: "Every cancer worker realizes that cancer of the breast in a woman under 40 years of age is a highly malignant disease and notwithstanding the most thorough surgical excision and large doses of radiant energy, the end results are very grave and disappointing."

Recently, however, this opinion seems to have been modified. De Cholnoky<sup>4</sup> writes that in a study based on 73 cases of mammary cancer in women under 30 years of age, the results of radical surgery are comparable to those obtained in the more advanced age groups. MacDonald,<sup>5</sup> in an analysis of 2,636 cases of mammary carcinoma, 1,511 five-year cures, and 1,125 recurrent cases, concludes that the age of patients with mammary carcinoma does not have the prognostic significance that is commonly accredited to it. He says, however, that the best results are obtained in those patients who are 35 to 50 years of age and the least favorable in those in the decade from 50 to 60.

In an excellent report Farrow<sup>6</sup> of New York calls attention to certain facts that must be borne in mind when considering the effect of hormones from the gonads on the progress of malignancy of the breast or the prostate. The gonads and their products have a remarkable degree of normal variation and a multiplicity of effect. And yet by integral relationship with other organs of the endocrine system, a hormonal balance is maintained. A disturbance of this balance as caused by menopause or by castration is usually followed by compensatory changes in other endocrine organs with a partial replacement by hormones or compounds having a similar biologic effect. Thus, Woolley, Fekete, and Little<sup>7</sup> found a nodular hyperplasia of the adrenal cortex and subsequent proliferation of the mammary epithelium following castration of both male and female mice. Riddle<sup>8</sup> has reported

that hormones capable of producing growth of the mammary tissues have been demonstrated not only in the ovary but in the pituitary, adrenal, and testes. Experimental data seem to indicate that an excess of sex hormones, whether from overactivity of the ovaries or testes or from artificial stimulation by the administration of preparations from these organs, will be similarly compensated by degeneration of other parts of the endocrine system. Such artificial stimulation is apparently a stronger influence for compensatory action than a natural overactivity.

It appears that susceptibility of response to stimulation by a specific hormone involves a hereditary factor as well as time and proper environment. Experimental and clinical data have shown that susceptibility varies in different species and in different organs, and in some instances is proportionate to the amount of hormones present. Hence, the sex hormone imbalance may be inconsistent.

Farrow says further, that in general it is believed that about one-third of the premenopausal cases of cancer of the breast can be materially benefited by castration.<sup>9</sup>

The beneficial influence of castration on mammary carcinoma has been observed in some cases. The fact that a few patients who have had bilateral oophorectomy for pelvic disease later developed cancer of the breast shows that the effect of castration in preventing mammary cancer is not universal, although it appears to be inhibitory.

Ewing pointed out that the cause of cancer may be classified as what he calls (1) the causal genesis, in which conditions are established that lead to the formation of cancer, and (2) the formal genesis, the biology and growth of the cancer cell itself.<sup>10</sup> After the causal genesis has created the conditions for the development of cancer, its function ceases and the growth of the cancer will continue of its own accord. This is well illustrated, for instance, in the carcinogenic agents, such as painting the ears of mice with coal tar or creating cancer by roentgen ray or ultraviolet light. After the cancer begins, the carcinogenic agent is unnecessary.

The relationship of the endocrines to cancer, however, seems to be of quite a different order, as Huggins has established in his experimental and clinical work on cancer of the prostate. It may well be that the hormones secreted by the ovaries act as both a causal genesis and a formal genesis of mammary cancer. Huggins and his associates have given a new light upon cancer.<sup>11-13</sup> Whatever may be the explanation of the benefits of orchietomy on cancer of the prostate, and they certainly exist in many cases, it would seem that an analogy might apply to bilateral oophorectomy in cancer of the mammary gland.

Halberstaedter<sup>14</sup> summarized the experimental evidence of castration and of estrin on mice and rats in regard to mammary cancer as follows:

1. Early castration of female mice reduces the incidence of carcinoma in strains which show a high percentage of spontaneous mammary carcinoma.<sup>15, 16</sup>

2. On the other hand, the administration of estrin increases the incidence of spontaneous carcinoma in female mice in strains which are characterized by a low percentage of spontaneous mammary tumor.<sup>17</sup>

3. Administration of estrin to male mice of such strains produces mammary carcinoma, though otherwise they never develop tumors.<sup>18, 19</sup>

4. Mammary carcinoma may be produced in male mice by implantation of ovaries following previous castration.<sup>20</sup>

5. Administration of estrin produces mammary carcinoma in rats belonging to a strain in which no spontaneous mammary tumors occur.<sup>21</sup>

6. The time required for the appearance of the mammary cancer was reduced if a higher daily dose was injected or if compounds of greater estrogenic potency were administered.<sup>21</sup>

While the causal relationship of excessive estrogenic substance to mammary cancer in mice and rats is quite clearly demonstrated, clinically this relationship is difficult to prove absolutely. However, cases in which it seems probable have been reported.<sup>22-26</sup> Hamblen states: "Untoward responses to estrogenic therapy are increasing since the availability of cheap, orally active estrogens of the diethylstilbestrol type; these are due chiefly to overdosage. Diligence to avoid over-treatment should be observed." It appears proved, however, both experimentally in mice and rats and clinically, that a family history of mammary carcinoma has much to do with the incidence of this disease.

That some cases of well-developed mammary cancer have been benefited by removing both ovaries is fairly well established. There are instances of apparently complete relief.<sup>27, 28</sup>

What seems to be the double role of estrin in the causal and in the formal genesis of mammary cancer resembles what might be the relationship between androgenic substances from the testicle and cancer of the prostate. The beneficial results of removing the ovaries along with a radical operation for cancer of the breast may be attributed to the withdrawal of a causal genesis, to the removal of a formal genesis, or to a combination of both of these factors. The recurrences of cancer of the breast after a radical operation are doubtless due to cancer cells that have been left. The small amount that remains, however, would be stimulated by estrogenic substances. As there have been cases in which cancer of the breast receded, at least temporarily, after removal of the ovaries with no other treatment, it would seem that there may be a mass relationship. That is, the effect of withdrawing

estrogenic stimuli might be greater if there are only a few cancer cells than if there is a large amount. This may be roughly compared, in reverse, with the action of the antitoxin of diphtheria, which must be given in at least a certain minimum quantity in order to obtain a desirable therapeutic result. When cancer is far advanced, it may be that changes occur in the metabolism of the cancer that will permit its growth and the cancer increases, even though the promoting influence from estrin is no longer present. With only a few remaining cancer cells, however, this unfavorable influence of withdrawing the stimulating effect of estrin should be more deleterious and create an unfavorable soil for their existence.

Complete abolition of all ovarian function cannot always be obtained except by bilateral oophorectomy. Huggins states that the interstitial cells of the testicle are not usually destroyed by irradiation.<sup>11</sup> The ovaries are much more protected from the effects of irradiation than are the testicles. Kaplan<sup>29</sup> reports twin pregnancy after temporary suppression of menstruation following roentgen-ray treatment for mammary cancer. This shows that sterilization by irradiation of the ovaries is not always effective. Some patient will doubtless react differently and require a larger dose of irradiation than others.

In women who have previously had cancer in one breast, the increase of ovarian activity in pregnancy appears to promote mammary cancer in the remaining breast. Trout<sup>30</sup> collected fifteen instances of pregnancy subsequent to a radical operation for mammary cancer, in thirteen of which there was prompt development of very malignant carcinoma in the remaining breast. Wintz<sup>31</sup> reported seven instances of pregnancy after radical operation for mammary cancer, with fatal cancer then occurring in the remaining breast.

My experience with the ultimate results of radical operation for cancer of the breast in young women has been rather disappointing (Table I). Of nine patients under 36 years of age, on whom radical operation

TABLE I

OPERATIONS FOR CARCINOMA OF THE BREAST IN PATIENTS UNDER 36 YEARS OF AGE  
BY J. SHELTON HORSLEY AT ST. ELIZABETH'S HOSPITAL  
(SEPT. 1, 1922, TO NOV. 1, 1937)

DATE	OPERATION	LOCAL X-RAY	AGE	BREAST	AXIL-LARY NODES	GRADE	RESULT
1. 9/13/22	Rodman	0	34	L.	x	4	Died, metastasis to spine
2. 7/ 8/25	Rodman	x	34	R.	0	2+	Died, metastasis to lungs
3. 8/ 5/25	Rodman	0	33	L.	0	3	Died, metastases to lungs and supraclavicular space
4. 9/ 8/28	Rodman	x	34	R.	x	4	Died, metastases to brain and lung
5. 3/19/31	Rodman	0	33	R.	0	2	Alive and well
6. 4/ 7/31	Rodman	0	33	R.	0	1+	Alive and well
7. 5/12/35	Rodman	x	34	R.	0	3	Died, metastases to bones
8. 4/16/36	Rodman	x	28	R.	0	4	Alive and well
9. 10/ 4/37	Rodman	x	35	L.	x	3+	Alive and well

Nine cases, 5 died with metastatic cancer; no local recurrences. (Note Case 6 was grade 1 with no axillary nodes involved.)

was done, from Sept. 1, 1922 to Nov. 1, 1937, five have had recurrence (55.5 per cent). In one of the cases without recurrence the cancer was grade 1 with no involvement of lymph nodes, a condition very favorable for cure. Of the total cases of radical operation (148, including these 9), for this same period, there was one operative death from septicemia. There were seventy-five recurrences (51.02 per cent). The results of experimental work on mice and rats which has been referred to, and the clinical results obtained by Beatson, Lett, Torek and others, showing occasionally some benefit in advanced mammary cancer after bilateral oophorectomy, caused me to adopt the procedure of removing both ovaries whenever a radical operation was done for cancer of the

TABLE II

RADICAL OPERATIONS FOR CARCINOMA OF THE BREAST WITH BILATERAL OOPHORECTOMY  
BY J. SHELTON HORSLEY AT ST. ELIZABETH'S HOSPITAL  
(Nov. 1, 1937, to Oct. 1, 1943)

DATE	OPERATION	AGE	BREAST	AXIL- LARY NODES	GRADE	RESULT
1. 11/19/37	Rodman	33	L.	x	4	Alive and well
2. 11/10/39	Rodman	38	R.	0	3+	Alive and well
3. 8/10/40	Rodman	42	L.	0	3+	Alive and well
4. 2/ 5/41	Rodman	38	L.	0	3	Alive and well
5. 2/14/41	Rodman	40	L.	x	2	Alive and well
6. 4/25/41	Rodman	47	R.	0	2	Alive and well
7. 4/26/41	Rodman	31	R.	x	3	Alive and well
8. 5/30/41	Rodman, bilat.	28	{R. L.	{x x	{3+ 3	Died 6 months after operation; metastases to lung and skin
9. 6/17/41	Rodman	38	L.	0	3	Alive and well
10. 9/ 1/41	Rodman	33	L.	x	4	Alive and well
11. 10/15/41	Rodman	40	R.	0	2	Alive and well
12. 1/13/42	Rodman	39	R.	x	3	Alive and well
13. 2/16/42	Rodman	47	L.	x	3	Alive and well
14. 3/21/42	Rodman	44	L.	x	3	Alive and well
15. 4/13/42	Rodman	43	R.	0	3	Alive and well
16. 6/15/42	Rodman	43	R.	0	{ 2 mucoid }	Alive with meta- stases
17. 7/ 4/42	Rodman	28	R.	0	3	Alive and well
18. 9/25/42	Rodman	35	L.	0	3	Alive and well
19. 10/ 5/42	Rodman	39	R.	0	3	Alive and well
20. 11/23/42	Rodman	30	R.	0	3	Alive and well
21. 2/23/43	Rodman	45	L.	0	3	Alive and well
22. 3/30/43	Rodman	44	R.	x	3	Alive and well
23. 7/ 8/43	Rodman	33	L.	x	3	Alive and well
24. 8/18/43	Rodman	37	L.	0	3	Alive and well
25. 9/22/43	Rodman	41	R.	0	2	Alive and well

NOTE.—It is, of course, not claimed that any of these patients are "cured" in the sense of an impossibility of a return of the cancer. It is well known that there are occasional cases of recurrence of cancer of the breast after much longer periods after operation than five years. All of these patients either have been examined by me or by some of my associates, or have been communicated with during the latter part of 1943 or later. The first patient (No. 1, Table II), who had a recurrence from a partial operation done elsewhere, was operated upon by me Nov. 19, 1937, more than six years and one month before submission of this article for publication. In my own experience the majority of recurrences from cancer of the breast occur within eighteen months after operation. It will be noted that the results in those cases without recurrence are classified not as "cured" but as "alive and well." In the last six cases in Table II the operations have been too recent to have significance as far as "so-called cure" is concerned, but in nineteen of the cases the results reported are for periods varying from fourteen months to about six years and one month after operation, with only two recurrences. All cases have been traced.



breast in young women. About four years after my first operation of this kind, which was on Nov. 19, 1937, the splendid report of Huggins on castration for cancer of the prostate appeared. His work seems to confirm the idea of bilateral oophorectomy in premenopausal women whenever a radical operation is done for cancer of the breast. This procedure apparently was first suggested by Schinzinger,<sup>22</sup> although according to his article, he did not carry it out. He is said to have discussed this also before the Surgical Congress in Berlin on April 25, 1899. Doubtless it has been performed by other surgeons, although there does not seem to be any systematic record of a number of cases.

At first I did bilateral oophorectomy with radical operation for cancer of the breast only on patients under 40 years of age. Later I extended it to all patients in the premenopausal stage. The desirability of having both ovaries removed along with the radical operation is, of course, first explained to the patient. At present I adopt the position that if the patient is unwilling to have this done, I will not treat her. Since extending this operation to all premenopausal patients there has been an increase in the number of these cases.

From Nov. 1, 1937 to Oct. 1, 1943, I have performed this operation of bilateral oophorectomy with the radical operation for mammary carcinoma on twenty-five patients, the first case on Nov. 19, 1937, the last on Sept. 22, 1943. There have been only two recurrences, one in a patient with bilateral mammary cancer who doubtless had internal metastases at the time of operation, although they could not be demonstrated then, and the other in a patient with mucoid cancer. Fourteen of these patients were operated upon since Jan. 1, 1942 (Table II).

A report of three of the earlier cases with previous incomplete operation or biopsy done elsewhere is of interest:

CASE 1 (No. 1 in Table II).—Mrs. C. B. A., age 33 years, had noticed a small lump in the left breast in January, 1937. Her mother died of nephritis and carcinoma of the left eye. On June 11, 1937, a left local mastectomy had been done elsewhere. Microscopic examination showed cancer. She then had thirty roentgen-ray treatments over the region of the left breast and axilla. Six weeks after these treatments she noticed a small lump in the left axilla and was given fifteen more roentgen-ray treatments, but the lump remained. Examination on admission to St. Elizabeth's Hospital, Nov. 18, 1937, showed the skin over the left thorax and left axilla brown from the roentgen-ray treatments and there were palpable lymph nodes in the left axilla. On Nov. 19, 1937, a radical operation for recurrent carcinoma of the left mammary gland and bilateral oophorectomy were performed. This was the first case in which this combined operation was performed. Microscopic examination of the axillary lymph nodes showed adenocarcinoma, grade 4. In some cells there was evidence of the effect of irradiation, but in most areas the cancer cells did not seem to be affected (Fig. 1). The patient was well, with no recurrence, on Feb. 10, 1944, more than six years and two months after operation. She appeared to be in perfect health.

CASE 2 (No. 3 in Table II).—Mrs. R. P. H., age 42 years, was admitted to St. Elizabeth's Hospital, Aug. 10, 1940. Three weeks before admission the patient

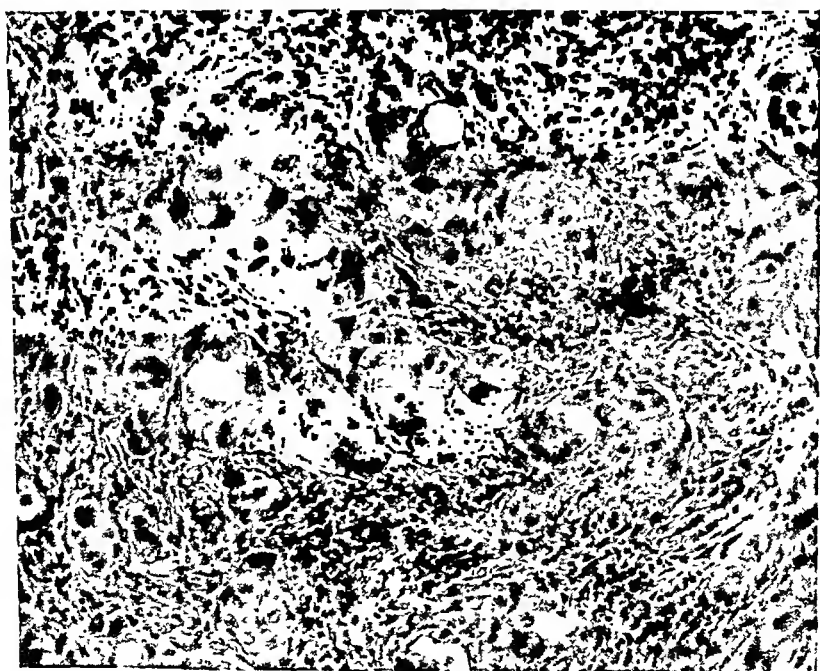


Fig. 1.—Case 1, Mrs. C. B. A., adenocarcinoma, grade 4 (X180).

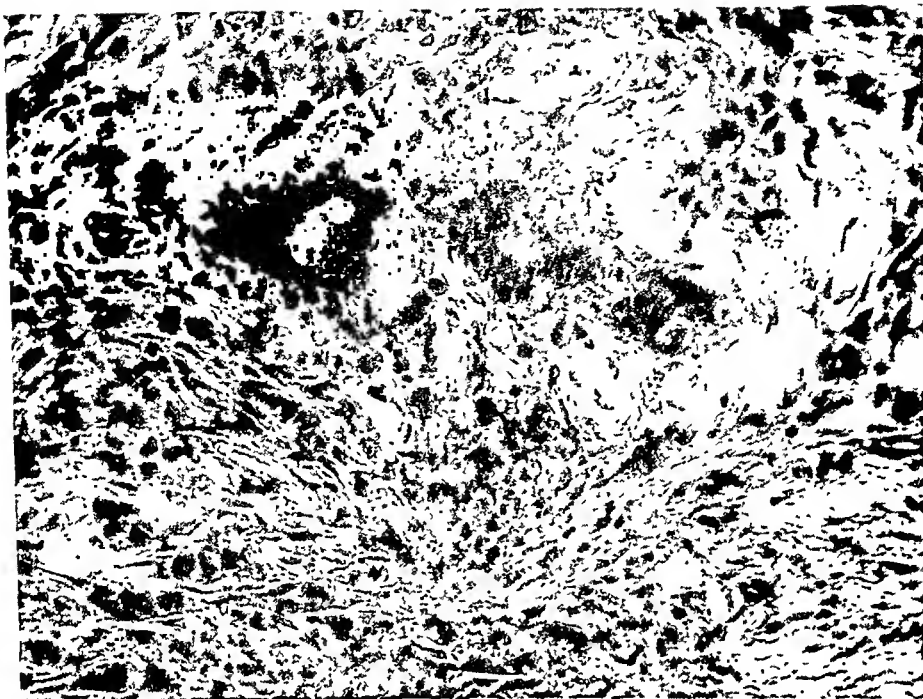


Fig. 2.—Case 2, Mrs. R. P. H., adenocarcinoma, grade 3 plus (X240).

had noticed a small, hard, painless mass in the upper outer quadrant of the left mammary gland. One week before admission the tumor had been removed elsewhere and microscopic examination showed cancer. She was otherwise in good condition. On Aug. 10, 1940, a radical operation for carcinoma of the left mammary gland and bilateral oophorectomy were performed. Microscopic examination showed adenocarcinoma, grade 3 plus (Fig. 2). The lymph nodes in the axilla were hyperplastic, but apparently not cancerous. This patient was in good health and had no recurrence when examined on Nov. 16, 1943, three years and three months after operation.

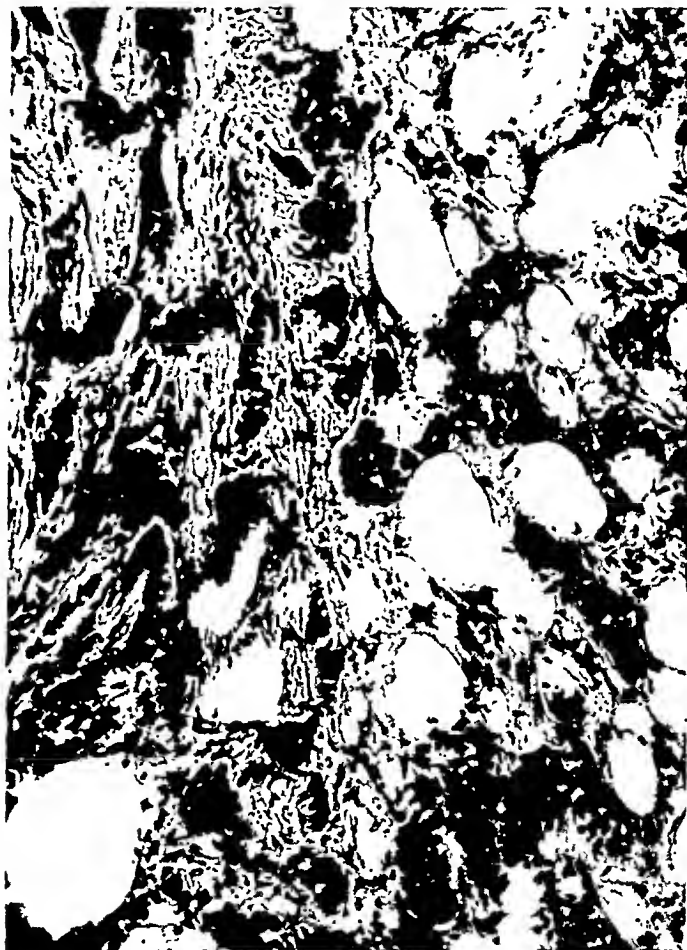


Fig. 3.—Case 3, Mrs. A. D. W., adenocarcinoma, grade 3 ( $\times 180$ ).

CASE 3 (No. 4 in Table II).—Mrs. A. D. W., age 38 years, was admitted to St. Elizabeth's Hospital on Feb. 3, 1941. Her mother died of cancer of the ovary. In June, 1940, a small tumor was removed from the patient's left breast elsewhere. Two months before admission to St. Elizabeth's Hospital she noticed another small tumor just lateral to the old incision. There had been infrequent sharp pains. On admission there was a scar in the upper outer quadrant of the left breast and near it were four firm, round tumors. There were no palpable lymph nodes in the axilla. Feb. 5, 1941, a radical operation for carcinoma of the left mammary gland

was performed with bilateral oophorectomy. Microscopic examination showed cancer, grade 3 (Fig. 3). When examined on Dec. 13, 1943, two years and ten months after operation, there had been no recurrence.

Another patient in this series is quite interesting:

CASE 4 (No. 7 in Table II).—Miss F. A., aged 25 years, was operated upon by me April 2, 1935, a radical operation being performed for cancer of the left mammary gland. Removal of a small tumor which was carcinomatous had been done elsewhere March 22, 1935. She married (now Mrs. G.) and had a baby. On April 23, 1941, a small tumor of the right mammary gland was removed elsewhere, with a histologic diagnosis of cancer. April 26, 1941, I performed a radical operation for cancer of the right mammary gland and bilateral oophorectomy. The baby was then about 18 months old. The patient was last examined on Nov. 1, 1943 and there was no evidence of recurrence.

It is well known that patients with cancer of the breast who have been previously operated upon by local removal of a cancerous tumor or by biopsy, with an interval of several days or longer before the radical operation, are much more likely to have a recurrence than those on whom a radical operation has been the primary procedure. All four of these cases are in this class. Case 4 also illustrates the observation made by Trout and others, that after removing one breast for cancer, pregnancy is prone to initiate cancer in the other breast.

CASE 5 (Mucoid cancer, No. 16 in Table II).—Mrs. F. H. S. had a radical operation for cancer of the right mammary gland and excision of both ovaries on June 15, 1942. Microscopic examination showed mucoid cancer (Figs. 4 and 5). The lymph nodes in the right axilla were enlarged, but microscopic examination showed only hyperplasia and no metastasis. This is the only case in the series of twenty-five in which there was mucoid cancer. The patient had arthritis involving the lumbar spine, which was revealed by roentgen-ray examination on Jan. 8, 1943. She continued to suffer indefinite pain, although there was then no evidence of local recurrence or of metastasis in the thorax or in the neck. Examination on Dec. 10, 1943 showed the scar in good condition and no evidence of recurrence, although there was much discomfort and pain, chiefly around the right hip and spine. Roentgen-ray examination, Jan. 31, 1944, revealed an erosion of the left eighth rib and the right seventh rib in the posterior axillary plane. There was also an absence of the spinous process of the fourth thoracic vertebra. These findings indicate metastases.

Ewing<sup>33</sup> states that the mucinous material in this type of cancer is usually in the stroma with the epithelium compressed in small islands of inactive cells. The mucoid substance is generally outside of and surrounding a group of compact, well-preserved cells. This is not in accordance with the epithelial origin of the mucinous material and has not been satisfactorily explained by those who maintain this origin. Ewing states, "In four cases I have not seen mucous degeneration of epithelium, but the compact alveoli lay in broad areas of mucinous stroma. There was strong evidence that the mucinous change had involved and partly originated in the fat tissue in the stroma."

The mucoid type of cancer of the breast is uncommon. It grows more slowly and apparently is less malignant than the usual type of

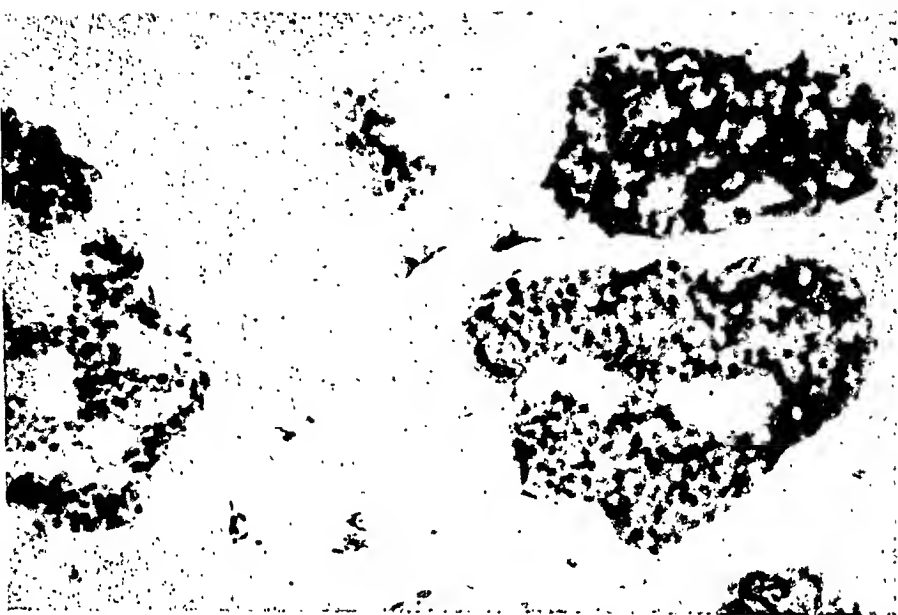


FIG. 5.—Case 5, Mrs. F. H. S., higher power from lower portion of Fig. 4 (marked off) ( $\times 240$ ). The epithelial cells do not appear to be active. It seems probable, as Ewing says, that the mucinous material originated from the stroma or from the fat in the stroma.

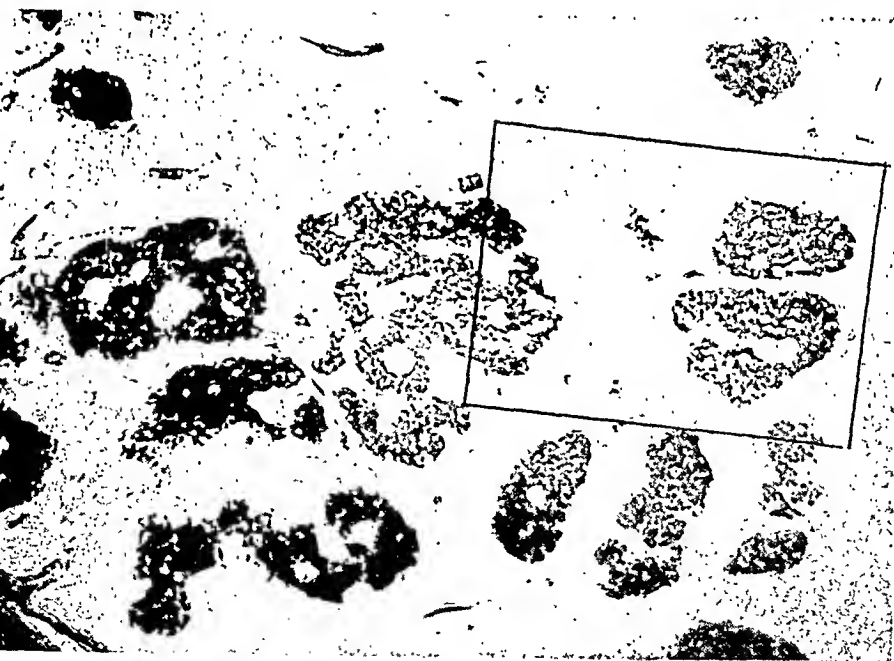


FIG. 4.—Case 5, Mrs. F. H. S., mucoid cancer of the breast showing islands of epithelial cells floating in a mucinous material ( $\times 108$ ).

mammary cancer. It tends to metastasize later. It would seem then that the pathogenesis of mucoid cancer of the breast differs from that of the usual mammary carcinoma, and it may well be that it is not influenced by estrin products, as it probably arises from the stroma. This is further emphasized by the fact that the epithelium in the islands in the mucinous substance is not active.

Therefore, it appears unnecessary to remove the ovaries in a case of mucoid cancer of the breast. The neoplasm should be examined immediately after the radical operation on the breast and before attempting a bilateral oophorectomy which seems to be efficient in preventing recurrence after a radical operation for the usual type of mammary cancer, but will doubtless be of no avail in mucoid cancer of the breast.

#### SUMMARY

The reasons for adopting bilateral oophorectomy along with the radical operation for mammary cancer in premenopausal women are discussed. The results of twenty-five cases so treated are presented.

#### REFERENCES

1. Ewing, James: *Neoplastic Diseases*, Ed. 4, Philadelphia, 1941, W. B. Saunders Company, p. 594.
2. Taylor, Grantley W.: *Artificial Menopause in Carcinoma of the Breast*, New England J. Med. 211: 1138, 1934.
3. Sittenfeld, Maurice J.: *Sterilization of the Ovaries as an Auxiliary Treatment in Cancer of the Breast*, Radiol. Rev. 59: 41, 1937.
4. de Cholnoky, Tibor: *Mammary Cancer in Youth*, Surg., Gynec. & Obst. 77: 55-60, 1943.
5. MacDonald, Ian: *Mammary Carcinoma*, Surg., Gynec. & Obst. 74: 82, 1942.
6. Farrow, Joseph H.: *The Effect of Sex Hormones on Skeletal Metastases From Breast Cancer* (in press).
7. Woolley, G., Fekete, D., and Little, C. C.: *Effect of Castration in the Dilute Brown Strain of Mice*, *Endocrinology* 28: 341-343, 1941.
8. Riddle, Oscar: *Lactogenic and Mammogenic Hormones*, J. A. M. A. 115: 2276-2281, 1940.
9. Horsley, J. Shelton: *Recent Advances in the Study of Cancer*, South. M. J. 36: 8-12, 1943.
10. Murphy, James B.: *An Analysis of the Trends in Cancer Research*, J. A. M. A. 120: 107-111, 1942.
11. Huggins, Charles: *Effect of Orchiectomy and Irradiation on Cancer of the Prostate*, Ann. Surg. 115: 1192-1200, 1942.
12. Huggins, Charles, and Hodges, C. V.: *Studies on Prostatic Cancer: I. The Effect of Castration of Estrogen and of Androgen Injection on Serum Phosphatases in Metastatic Carcinoma of the Prostate*, Cancer Research 1: 293, 1941.
13. Huggins, Charles, Stevens, R. E., Jr., and Hodges, C. V.: *Studies on Prostatic Cancer: II. The Effects of Castration on Advanced Carcinoma of the Prostate Gland*, Arch. Surg. 43: 209, 1941.
14. Halberstaedter, L.: *The Role of Artificial Menopause in the Treatment of Cancer of the Breast*, J. Internat. Coll. Surgeons 4: 435, 1941.
15. Loeb, L., and Lathrop: *J. Cancer Research*, 1916.
16. Cori, C. F.: *Influence of Ovariectomy on Spontaneous Occurrence of Mammary Carcinoma in Mice*, J. Exper. Med. 45: 983, 1927.
17. Lacassagne, A.: *Métaplasie épidermoïde de la prostate provoquée, Chez la souris par des injections répétées de fortes doses de folliculine*, Compt. rend. Soc. de biol. 113: 590, 1933.
18. Lacassagne, A.: *Hormonal Pathogenesis of Adenocarcinoma of Breast*, Am. J. Cancer 27: 217, 1936.

19. Bonser, G. M.: Comparison of Normal Oestrous Cycle and of Response to Administration of Oestrin in Two Strains of Mice Differing Greatly in Incidence of Spontaneous Mammary Cancer, *J. Path. & Bact.* 41: 32-42, 1935.
20. Murray, W. S.: Ovarian Secretion and Tumor Incidence, *J. Cancer Research* 12, 18, 1928.
21. Geschickter, Charles F.: Estrogenic Mammary Carcinoma in Rat; Mammary Carcinoma in Rat With Metastasis Induced by Estrogen, *Science* 89: 35, 1939.
22. Allaben, G. R., and Owen, S. E.: Adenocarcinoma of the Breast Coincidental With Strenuous Endocrine Therapy, *J. A. M. A.* 112: 1933, 1939.
23. Auchincloss, Hugh, and Haugensen, Cushman, D.: Cancer of the Breast Possibly Induced by Estrogenic Substances, *J. A. M. A.* 114: 1517, 1940.
24. Parsons, Willard H., and McCall, Eugene F.: The Role of Estrogenic Substances in the Production of Malignant Mammary Lesions—With Report of a Case, *SURGERY* 9: 780-786, 1941.
25. Geschickter, Charles F.: *Diseases of the Breast*, Philadelphia, 1943, J. B. Lippincott Company, p. 274.
26. Hamblen, E. C.: Use of Female Sex Hormone in Clinical Practice, *Surg., Gynec. & Obst.* 74: 490-494, 1942.
27. Lett, Hugh: An Analysis of 99 Cases of Inoperable Carcinoma of the Breast Treated by Oophorectomy, *Lancet* 1: 227-228, 1905.
28. Torok, Franz: Disappearance of Recurrent Mammary Carcinoma After Removal of the Ovaries, *Ann. Surg.* 60: 476-477, 1914.
29. Kaplan, I. I.: Twin Pregnancy After Temporary Suppression of Menstruation Following Roentgen-Ray Treatment for Mammary Cancer, *Am. J. Obst. & Gynec.* 14: 40, 1927.
30. Trout, H. H.: The Remaining Breast After Radical Removal of the Opposite Side for Carcinoma, *Surg., Gynec. & Obst.* 34: 630, 1922.
31. Wintz, H.: Experiences in the Irradiation of Breast Cancer, *Brit. J. Radiol.* 31: 150, 1926.
32. Schinzinger: Carcinoma of the Mammary Gland, München. med. Wchnschr. 52: 1724, 1905.
33. Ewing, James: *Neoplastic Disease*, Ed. 4, Philadelphia, 1941, W. B. Saunders Company, pp. 569-570.

## INTERNAL FIXATION OF FRACTURES OF THE PATELLA WITH COTTON SUTURE MATERIAL

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VARIOUS suture materials have been used for internal fixation of fractures of the patella including iron alloy wire, silver wire, silk, linen, catgut, and kangaroo tendon. The multiplicity of materials used at once suggests the inadequacy of any one of them.

In 1939, Meade and Ochsner<sup>2</sup> emphasized the advantages of cotton suture material experimentally and clinically in general surgery and it is now the consensus of opinion that cotton as compared with other materials produces the least amount of tissue reaction and yet maintains its tensile strength.

Although today wire is the most popular suture material for repair of fractures of the patella, experience has shown that cotton has many superior qualities: (1) Undesirable electrolytic reactions which are associated with wire do not occur with cotton. Electrolysis causes disintegration of metal which results in increased tissue reaction and weakening of wire.<sup>3</sup> (2) Cotton may be tied rather than twisted and thus breaking either at the time of operation or later is not a problem. (3) Joint reactions often associated with the presence of wire<sup>6</sup> have not been observed with cotton.

Other noteworthy attributes of cotton have demonstrated its advantages over silk, linen, kangaroo tendon, and catgut, which are less commonly used than wire in repairing patellar fractures: (1) Cotton can be easily and thoroughly sterilized by boiling for twenty minutes or autoclaving for ten minutes at fifteen pounds' pressure.<sup>4</sup> Of course, in boiling, shrinkage of the material must be considered and the cotton should not be wound on a rigid spool. (2) Cotton maintains its tensile strength 100 per cent at the tenth day of wound healing.<sup>3</sup> (3) It causes little tissue reaction.<sup>3</sup> (4) A practical consideration is the availability of mercerized or nonmercerized cotton at any dime store at nominal cost.

In this study, cotton suture material was used for internal fixation of simple transverse fractures of the patella having wide separation of fragments. In this type of fracture it is usually possible to secure *an exact reduction with a smooth articular surface* by operation.

### TECHNIQUE

Following a forty-eight-hour skin preparation, under general anesthesia, a slightly curved transverse incision is made from medial to

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lateral femoral condyle, the apex of the incision being slightly distal to the distal fragment (Fig. 1a). Bleeding points are ligated with fine cotton (No. 80), skin draping is affixed, fragments are exposed, and interposing soft parts removed. The knee joint is thoroughly irrigated with warm normal saline solution and old clots removed. With a seven-sixty-fourths-inch drill a transverse hole is made in each fragment about one-half inch from the fracture line (Fig. 1b and c) and a double strand of crochet cotton (No. 10), which has been previously wet and tested by the operator to show up possible defects in the suture, is threaded on a Keith needle or probe, passed through the holes, and tied firmly with a triple knot while the assistant holds the fragments in apposition. Two accessory anterior sutures of No. 10 cotton are then placed after ap-

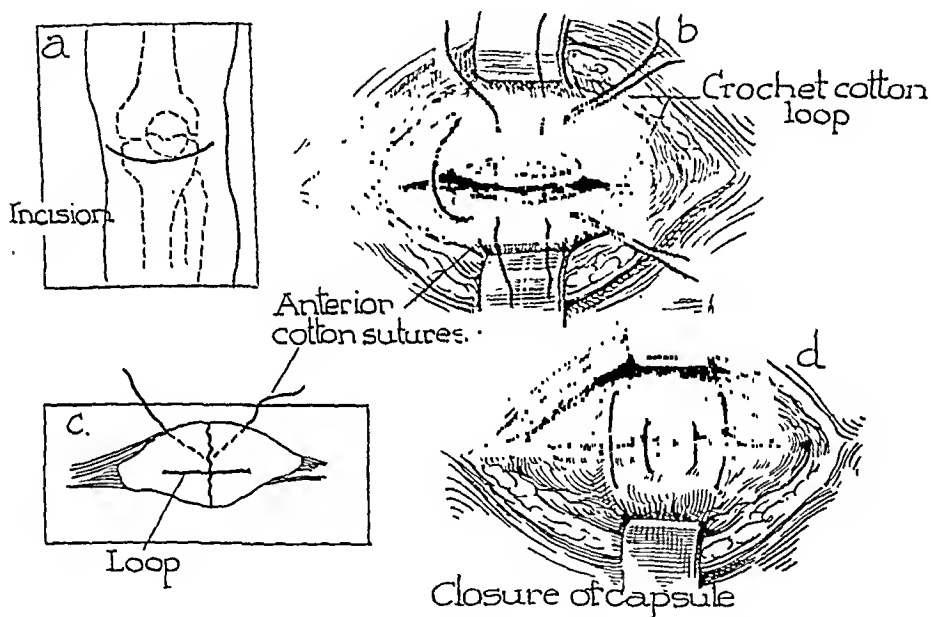


Fig. 1.—(a) Slightly curved transverse skin incision, (b) double strand No. 10 crochet cotton loop and two anterior sutures of crochet cotton, (c) sagittal section showing loop and anterior suture through patella. (d) Patella is repaired with crochet cotton and capsule closed with interrupted sutures of quilting cotton.

propriate holes have been drilled (Fig. 1b and c). Drill holes must never penetrate or undermine articular cartilage. The knee is flexed slightly to determine whether the fracture is securely fixed and the articular surface of the patella is checked for anatomic reduction. The articular capsule and the quadriceps expansion are then repaired medial and lateral to the patella with interrupted sutures of quilting cotton. These sutures are all inserted before any one of them is tied in order to create equal tension on all sutures, and are closely spaced to obtain hemostasis in the synovial capsule (Fig. 1d). The subcutaneous tissues and skin are approximated with interrupted sutures of quilting cotton. The wound is dressed, a posterior plaster splint is applied from the ischial

tuberosity to beyond the toes with the knee in extension, and the hip is flexed to 135 degrees for two days to relax the rectus femoris muscle. After three weeks the splint is removed and active motion, heat, and massage are started.

A midthigh tourniquet is not used because it frequently interferes with passive stretching of the quadrieeps group, especially the rectus femoris, and thereby makes apposition of fragments more difficult.

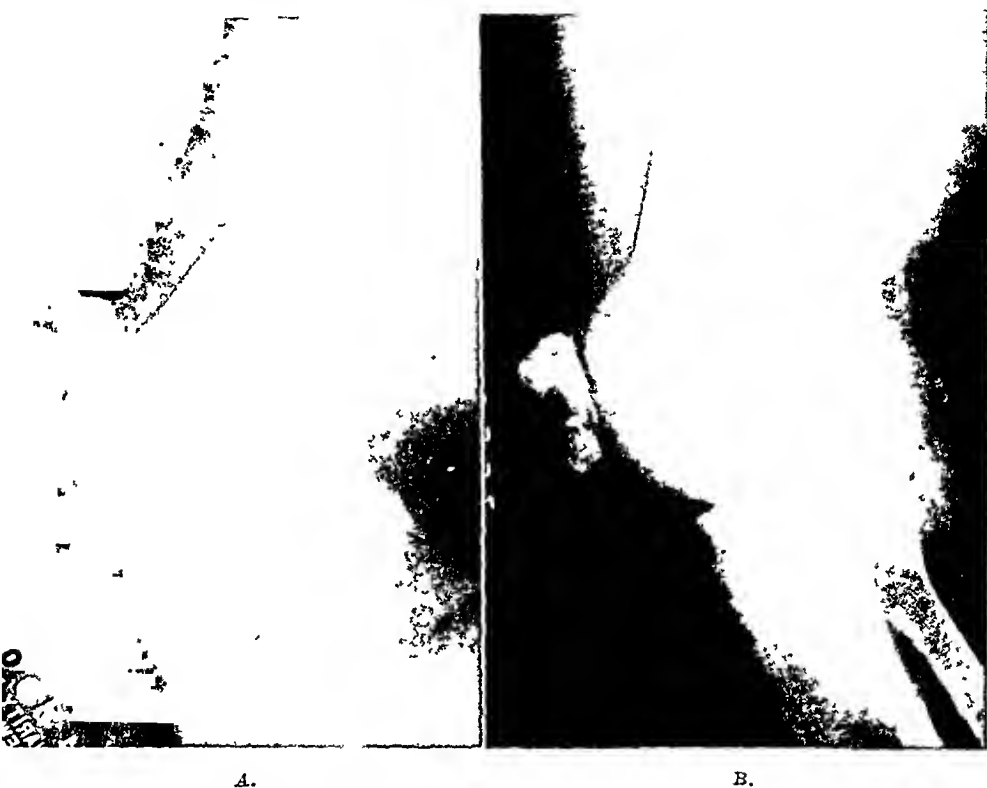


Fig 2—A, Transverse fracture showing patella with separation of fragments B, Same patient seven weeks following repair of patella with cotton; this patient had a complete painless range of motion at this time.

#### DISCUSSION

Eleven patients with patellar fracture have been treated by this method and a similar procedure has been employed in seven cases of transverse intra-articular fracture of the olecranon process. The crochet cotton loop and a similar technique have also been used by Dixon<sup>1</sup> in six cases of patellar fracture. In none of these twenty-four cases has there been any wound infection and in no case has removal of the cotton loop been necessary. All of the patients had a useful range of motion within six to eight weeks and were able to resume their regular occupations at that time (Fig. 2A and B). As might be anticipated, there is minimal joint effusion and minimal local reaction to the cotton loop and cotton sutures.

Of minor consideration is the fact that cotton, unlike wire, does not appear in the x-ray film and with certain patients this has a psychologic advantage.

#### REFERENCES

1. Dixon, J. L.: Personal communication.
2. Meade, W. H., and Ochsner, A.: *J. A. M. A.* 113: 2230-2231, 1939.
3. Meade, W. H., and Ochsner, A.: *Surgey* 7: 185-511, 1940.
4. Thorek, P., Gradman, R., and Glaess, A.: *Am. J. Surg.* 59: 68-71, 1943.
5. Venable, C. S., and Stuck, W. G.: *J. A. M. A.* 111: 1349-1352, 1938.
6. Watson-Jones, R.: *Fractures and Other Bone and Joint Injuries*; ed. 2, Baltimore, 1941, Williams & Wilkins Company.

# EXPERIMENTAL HEAD INJURY PRODUCED BY BLASTING CAPS

## AN EXPERIMENTAL STUDY

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RECENT studies indicate that head traumas vary in character with the type and amount of violence applied. During the present war it has been observed repeatedly that patients with penetrating wounds of the head or localized depressed fractures were not unconscious.<sup>1, 2</sup> The studies of Denny-Brown and Russell<sup>3</sup> have shown that concussion, as they defined the word, resulted from a blow upon a large surface of the skull which, as a rule, produced no fracture. They also showed that the strength of the blow was an important factor in producing concussion; they measured this amount of violence, and expressed it in terms of "head acceleration" (28 feet per second).<sup>3</sup>

It is clear, therefore, that the approach to the problem of the closed head injury must be made under well-defined standardized conditions in the laboratory. Previous experimental work on head injury is open to criticism because of the techniques employed in producing the trauma. As Denny-Brown and Russell<sup>3</sup> pointed out, most investigators have fixed the head before delivery of the blow. Frequently, multiple hammer blows of unequal and unknown intensities producing localized depressed fractures have been used.<sup>4-6</sup> Other workers have employed mechanical devices, such as falling objects and pendulums, and left it uncertain if any serious injury was produced after a single blow.<sup>7, 8</sup>

To produce a severe type of standardized head trauma without fracturing the skull at the site of impact, it was felt that the following criteria should be satisfied:

1. The same amount of violence should be employed in all experiments.
2. The skull should remain intact at the site of impact.
3. The animal should be severely disabled as a result of the single blow.
4. The head should be freely movable.
5. The trauma should be confined to the head only.

In our experience with the adult dog, these criteria cannot be satisfied by the usual mechanical devices used to produce experimental head

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injury. Following single blows with the pendulum or falling objects, even when concussion occurs, the dogs show little disability after an hour and seem to recover completely. Manually delivered blows with a baseball bat or mallet at times produce a seriously disabled dog, but possess the obvious disadvantage of not being uniform. We found that the criteria mentioned here could be fulfilled by using a standard commercial blasting cap which could be applied to any chosen surface of the head. The explosive used in this study inflicted violence which was well localized to the head, and in no way produced any injury to the lungs or other major organs. The purpose of this communication is to report the experimental technique used to produce head injury, the accompanying neurologic findings, and the gross pathology. The histopathology of the brains will be reported in a later article.

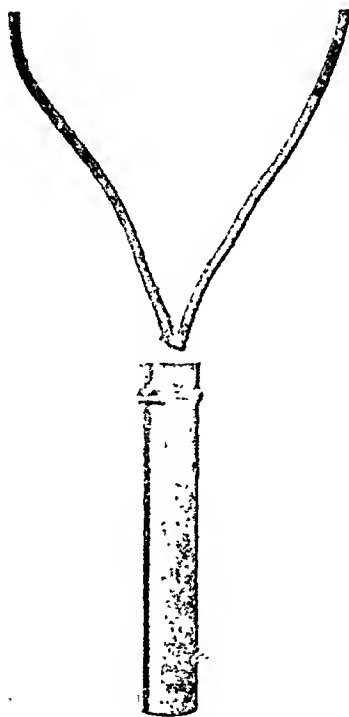


Fig. 1.—Du Pont No. 6 electric blasting cap.

The explosive selected was the du Pont No. 6 Electric Blasting Cap. Its chief commercial function is detonation, and it is used to fire high explosives. Mr. F. F. Chapman of the explosives department of the E. I. du Pont de Nemours & Company was kind enough to furnish the following information and the accompanying sketches (Figs. 1 and 2).

“The standard du Pont No. 6 Electric Blasting Cap has a  $1\frac{5}{8}$  inch long copper shell containing a base load of tetryl, a pressed primer load,

and a loose ignition charge. The electrical firing element consists of two leg wires, a sulfur composition bridge plug which holds the two leg wires in place, and a small diameter corrosion-resistant bridge wire attached across the terminals of the leg wires about  $\frac{3}{16}$  inch below the plug. This firing element is placed in the cap so that the bridge wire is embedded in the loose ignition charge, and then sealed in place by a pour of water proofing material and finally a pour of sulfur. Upon application of electrical current the bridge wire heats up to incandescence and fires the cap. The detonation speed of tetryl, the base charge material in the cap, is approximately 17,000 feet per second. We are unable to give any information regarding the distance through which the detonation acts. In regard to translation of the explosive force into mechanical terms, we have calculations which show that the total charge in a No. 6 Electric Blasting Cap produces detonation forces equivalent to 477 gram calories per cap."

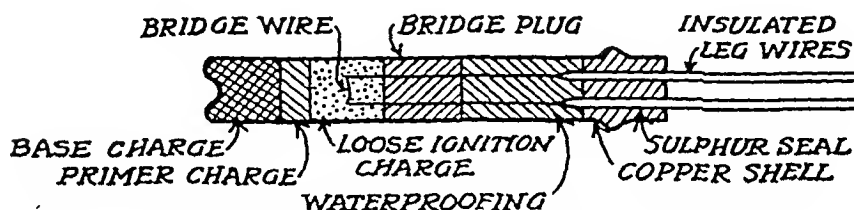


Fig. 2.—Longitudinal section through the du Pont No. 6 electric blasting cap.

#### METHODS

Adult dogs weighing between 6 and 20 kg. were used in all experiments. Preliminary examinations included gait, ability to jump, eye grounds, reflexes, placing and hopping reactions, cardiac and respiratory rates, rectal temperature, and femoral blood pressure. The cerebrospinal fluid pressure was measured by inserting a needle in the cistern after novocainization following the method described by Webster and Freeman.<sup>4</sup> When measurements were repeated, twenty-four hours were allowed to elapse between repetitions. The femoral blood pressure was measured with the usual laboratory mercury manometer after inserting an 18-gauge needle into the artery.

Prior to inflicting the trauma, the animals were lightly anesthetized with ether for from three to six minutes. The anesthetic was then discontinued, several turns of bandage wound about the head, and the blasting cap fixed to the desired location with adhesive tape. The dog was laid on its side and the head placed in an ordinary bucket to prevent the scattering of bits of copper. The cap was then fired. Respiration ceased immediately with the chest in inspiratory apnea, and the usual reflexes could not be elicited. In ten to ninety seconds respiration was resumed, either spontaneously or after a few compressions of the chest. When prolonged artificial respiration was necessary, the animal almost

invariably died. Five animals were not anesthetized. In all animals, a scalp laceration about 4 cm. in diameter occurred. Bleeding was stopped immediately by a pressure bandage and suture of the scalp. The wound healed in two to three weeks. In surviving animals, there was no evidence of skull fracture; an occasional animal killed outright by the force of the explosion showed a linear fracture across the longitudinal axis of the vault. For the first three to four days following the injury the surviving animals refused food and water and were tube fed daily with 500 to 1,000 c.c. of milk.

Two precautions were necessary in placing the blasting cap: (1) The cap should be taped securely to the head, or no effect could be expected on the animals. (2) The cap should not be placed over the frontal region of the head, because it caused depression fractures into the frontal sinuses accompanied by paraplegia, which did not occur in closed head injury. Aside from these precautions, it made little difference what areas were chosen for placing the cap, since the same neurologic disorder was always obtained. The sites best suited for placing the cap were the external occipital protuberance, the area just above the zygoma, and the parietal areas.

## RESULTS

### 1. Fatalities.—

*Immediate Death:* Of thirteen animals which died as a direct result of the trauma to the head, nine died immediately. In these dogs respirations ceased and never returned, and after a short variable interval of five to ten minutes, the cardiac pulsations could no longer be heard, even though artificial respiration was maintained. During the interval between cessation of respiration and heart beat, all reflexes—corneal, pupillary, patellar, withdrawal—were absent. Gross examination of the brains in this group showed a varying degree of trauma as judged by the amount and location of hemorrhage. Three animals showed an insignificant degree of subarachnoid bleeding without any evidence of hemorrhage in the nervous substance; in two there was marked intracerebral hemorrhage; the remainder commonly showed petechial hemorrhages (one to five in number) usually in the brain stem and occasionally in the cerebral hemispheres (Fig. 3).

*Postponed Death:* Four animals showed what might be termed a postponed death. After an initial stage of apnea and areflexia, spontaneous respiration was resumed and the reflexes returned. The animals were flaccid and appeared to be in deep coma. The respirations were slow and shallow. Aside from occasional blinking no active movements occurred. In one-half to one and one-half hours respirations ceased. Shortly prior to death the pupils became fixed and the corneal reflex disappeared, although the patellar and withdrawal reflexes could still be elicited. Delayed deaths in the clinical sense, that is occurring twenty-four to forty-eight hours after head injury, were never observed



Fig. 3.—Immediate death. Cross section through the brain at the level of the optic thalamus and through the medulla oblongata at the level of the cochlear nuclei. Hemorrhages<sup>21</sup> into the reticula substance of the latter and in the dorso medial part of the left optic thalamus.



Fig. 4.—Postponed death. Numerous pin-point hemorrhages into the cerebellar hemispheres and into the medulla oblongata. Larger hemorrhages into the anterior and posterior colliculi extending into the aqueduct.



in this study. At necropsy, two animals showed a minor degree of subarachnoid blood without involvement of the brain substance. In the others, a variable amount of hemorrhage into the nervous substance was found with petechial hemorrhages into the brain stem (Fig 4).

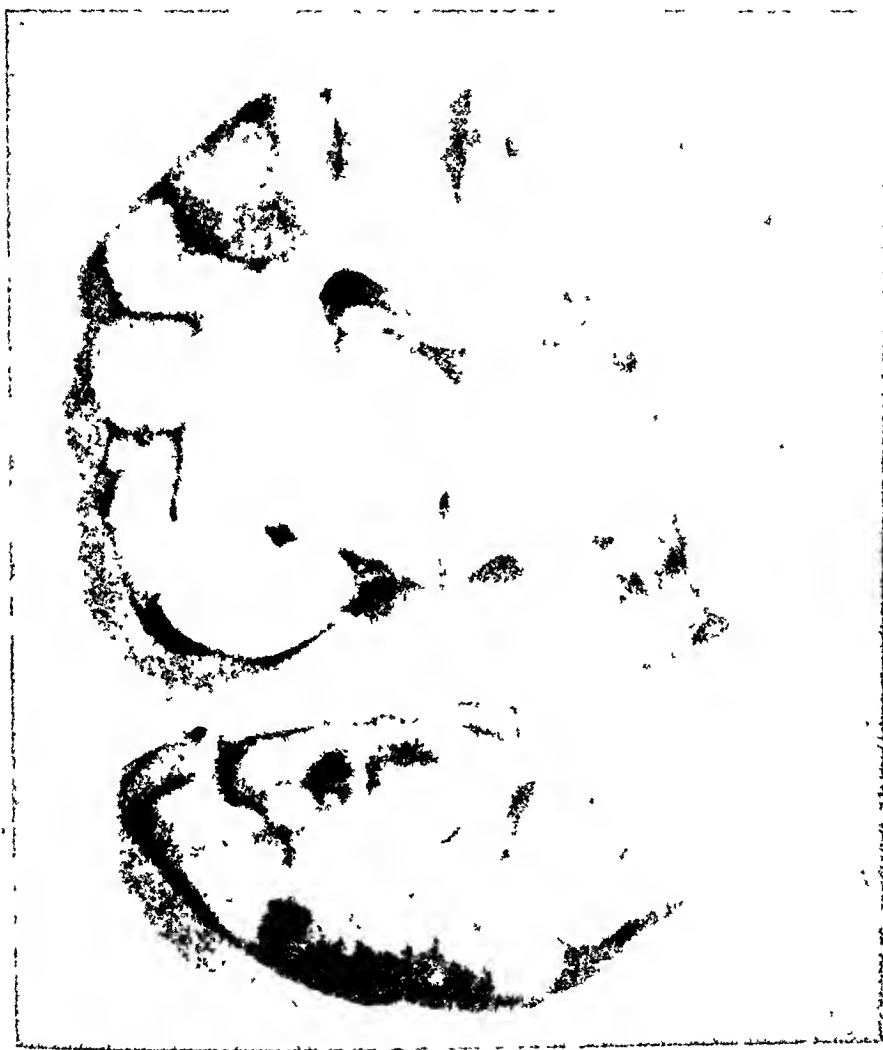


Fig 5—Surviving dog. Hemorrhagic contusion by direct impact of the blast on the right occipital lobe close to the surface. Hemorrhages into the temporal lobe and in the internal capsule at the level of the optic thalamus.

2. *Surviving Animals.*—Seventeen dogs survived the immediate effect of the trauma. Five of these died of unavoidable complications, namely one on the fourth day following the accidental aspiration of milk; one on the third day, due to meningitis; and three on the seventh, eighth, and tenth days, respectively. The latter were found dead in their cages after apparent improvement, and no cause for the death could be found at necropsy. These deaths were probably not related to the head trauma, since they occurred during a heat spell at a time when deaths among

normal animals were not infrequent. Most of the remaining twelve animals were sacrificed between the fifteenth and twenty-fifth day after trauma. Two animals were still being observed eight months after injury.

The surviving dogs presented a syndrome characterized by somnolence, inability to stand, ataxia, and salivation in the early phase, and by difficulty in jumping, disturbance of gait, and tendency to circle walking in the final phase. The early phase lasted from one to seven days, the final phase, for the duration of the observations.



Fig. 6.—Surviving dog. Hemorrhage into the midline of the medulla oblongata at the level of the cochlear nuclei.

The sequence of events following detonation was: The corneal reflex disappeared for a period of from ten to ninety seconds and the animals became apneic. Respiration was resumed spontaneously or after a few compressions of the chest. After five to ten minutes, blinking returned. For the next several hours, the majority of dogs lay practically motionless on their side. If put on their limbs, they slumped. Occasionally they lifted the head for short intervals, or made feeble movements with the limbs. When the head was lifted passively and released, it fell with a thud to the floor. For the most part the eyelids were kept closed as if in sleep, but were opened when the fur was ruffled. Loud noise, as bursting a paper bag or dropping a bucket beside the head, produced no response. Drooling frequently persisted for forty-eight hours. Obnoxious odors, as ether or cigarette smoke, caused withdrawal of the head.

A second group of dogs showed, in contrast to this picture of inactivity, pronounced incoordinate motor hyperactivity. In an effort to stand, they thrashed about wildly, leaped at times fully one foot from

the floor and fell heavily. When exhausted, they wallowed confusedly, or tossed the head aimlessly and bewildered from side to side. Saliva drooled from the mouth, and often a coarse nodding head tremor was present. Sometimes they crawled on flexed limbs. Between periods of violent activity, they dozed quietly, but it aroused by being placed on their limbs, their wild ataxic struggle was resumed. These movements had no definite pattern, and rarely showed the irritative signs of rolling, circling, or gyration which are described following labyrinthectomy. Except for the first hour following the trauma, nystagmus was conspicuously absent. After five to six hours this motor activity disappeared gradually and the picture resembled that of the first group of animals.

In one to seven days, usually two to four, the animals regained the ability to stand. The gait was halting, the dog tottered and fell frequently. By the end of a week all animals presented an almost uniform picture which persisted for many months, probably permanently. They walked with a broad base, more noticeable in the hindlimbs. The head was usually kept downward, pointed to the floor, tilted and rotated somewhat toward the blasted side. Often they stumbled or reeled. They would not stand on their hindlimbs to obtain food; in some instances, when such an attempt was made, the dog fell backward. When fed by hand, a slight but distinct head tremor was present. The dogs were not agile in retrieving thrown objects; often the object was not found unless it was rolled slowly and not too far. Some animals walked at times in circles, predominantly toward the blasted side. This movement occurred in all animals after blindfolding. In "shuddering," the movement began in the head and forebody, increased in intensity as it progressed backward, and ended with a distinct flip to the rear. All animals were unable and refused to jump from distances as low as one to two feet, falling awkwardly when the attempt was made.

*Neurologic Examination.*—Except for transient minor deviations from the normal shortly after the blast, the examination showed normal hopping and placing reactions, adequate pupillary, corneal, patellar, withdrawal, and tonic neck and body reflexes. The eye grounds were normal. Nystagmus, although frequently observed early after injury, seldom persisted and was not a prominent feature. None of the animals was blind. No definite conclusion could be reached as to the degree of hearing impairment, although it was felt that the animals were probably deaf in the early phase. Hemorrhage from the ear was not observed and the drum heads were always found intact at necropsy. A few dogs showed bloodstained mucus in the nostrils; infrequently, ecchymoses of the ocular conjunctiva were observed. The cardiac rate was frequently slowed to a range between 60 to 70 beats per minute, which persisted for two to three days and gradually increased with the resumption of activity. When slowing of the pulse occurred, it ap-

peared within several minutes after the injury. The femoral blood pressure and the rectal temperature remained remarkably constant and showed no deviation from the pre-experimental studies. The cerebrospinal fluid was blood tinged and contained from 2,000 to 5,000 red blood cells on the day of injury, clearing in about four days. A moderate elevation of pressure was consistently observed. This ranged from 180 to 325 mm. of water pressure as compared to pretraumatic readings of 90 to 160.

Further neurologic examination showed that the difficulty in jumping so persistently present in surviving animals was caused by the absence of the labyrinthine righting reflexes. When a normal blindfolded dog held by the pelvis suspended in mid-air was suddenly released, the limbs become extended and the animal landed on its feet. In the traumatized dogs, this reflex extension of the limbs did not take place and the animal landed on its belly, even when not blindfolded. In three animals which were tested, another consistent neurologic sign was the absence of after-nystagmus following rotation in a Bárány chair. These animals accepted food immediately after rotation, suggesting an absence of vertigo.

The gross necropsy findings of the brain in this group of animals again showed a lack of uniformity. In four brains there was no evidence of contusion or hemorrhage. Eight animals showed a superficial contusion of the cortex at the site of impact, although the skull and dura remained intact. In two, this was the sole demonstrable lesion. The remaining six showed, in addition to the local trauma, one to five small hemorrhages, usually in the brain stem, infrequently in the hemispheres. In one animal, no contusion of the cortex was found, the only gross lesion seen was a petechial hemorrhage in the midline of the midbrain in the region of the brachium conjunctivum.

#### DISCUSSION

These results indicate that the labyrinthine system is consistently involved in all dogs surviving our experiments. This syndrome, characterized by an absence of postrotatory nystagmus, impaired labyrinthine-righting reflexes, circle walking, and inability to jump, has not been described, as far as we know, in the literature on experimental head trauma. Duret (1878)<sup>9</sup> occasionally noted motor incoordination and ataxia following experimental head injury in dogs, which he termed "locomotor ataxia traumatique." He felt that these signs were connected with hemorrhages in the upper cervical cord. Jakob (1912)<sup>7</sup> seems to have observed at times a similar picture in rabbits as the result of repeated blows upon the head. He concluded, however, that there was no relation between the severity and frequency of the trauma, on the one hand, and the consequent functional and pathologic disturbances, on the other.

Although a constant physiologic disturbance followed the standardized trauma in our experiments, the amount of damage to the brain was variable. The most frequent gross lesions found were small hemorrhages into the brain stem, occurring in half of the animals. A few animals, even upon microscopic examination of the brain (to be reported in a later article), showed only insignificant alterations from the normal. The syndrome, therefore, cannot be attributed to a damaged brain. Rademaker<sup>10</sup> and others have shown that the centers for the labyrinthine-righting reflexes are in intimate association with those of the body-righting reflexes, and that these centers are located in or about the red nucleus. In our animals the body-righting reflexes were normal. It is difficult to conceive of gross trauma applied to almost any portion of the skull constantly producing selective destruction of certain nerve cells leaving adjacent centers intact. The loss of postrotatory nystagmus again points to the labyrinth as the organ damaged. Persistent loss of the ability to jump with loss of postrotatory nystagmus is known to follow labyrinthine destruction in dogs.<sup>11</sup> Dow<sup>12</sup> has shown that the vestibular-righting reflexes are similarly and permanently lost following labyrinthectomy in primates, the effects being most marked in the monkey and least in the chimpanzee. Here, again, the most prominent finding, in addition to the loss of postrotatory nystagmus, was the absence of extension of the limbs when the animals were allowed to slide down an inclined plane. "Animals without labyrinths, lacking such extension when blindfolded, fell away from the inclined plane, and at times rolled completely over as an inert mass." Although the labyrinthine lesions have not been verified histologically, in our animals, the evidence strongly points to these organs as the site of damage.

Reports in the literature presenting evidence of damage to the labyrinth in man following head injury are abundant. This literature has been ably reviewed by Linthicum and Rand<sup>13</sup> and need not be restated here. Brümmer,<sup>14</sup> using repeated blows upon the heads of guinea pigs as the method of trauma, found hemorrhage, exudates, and edema in various portions of the inner ear, even though no gross abnormality in muscular coordination of the animals was reported. He confirmed these pathologic findings in human necropsies following deaths from head injuries. Linthicum and Rand, discussing their observations in patients following concussion of the brain, found that "in practically all cases of cerebral concussion the patient complains of some form of equilibratory disturbance," and this disturbance could be demonstrated by adequate neuro-otologic examination. More recently Russell<sup>15</sup> expressed the opinion that "... true vertigo which often follows head injuries is probably due to concussion of, or hemorrhage into, the labyrinth." He emphasized the importance of this type of damage as a cause of incapacity following head injury.

The role of the labyrinths in the clinical condition designated as "cerebral concussion" is unknown. One might speculate as to whether

the clinical symptoms, both early and late, could be attributed to sudden cessation of function of these organs with partial or complete recovery. It is conceivable that concussion may result from widespread inhibition of the central nervous system acting through a reflex, possibly originating in the labyrinths. This theory is supported by investigations dealing with the role of head acceleration in experimental head trauma. Denny-Brown and Russell<sup>2</sup> found that "concussion" ensued when the degree of trauma applied to the freely movable head reached a critical acceleration of 28 feet per second. When the head was fixed, far greater forces were necessary to produce "concussion." We have estimated the head acceleration of our dogs, by means of rapid cinematographic films taken at the time of the explosion, to be in the neighborhood of 64 feet per second. Under these experimental conditions, fixation of the head did not alter the results. The trauma produced by the blasting caps was obviously of much greater force than that reported by Denny-Brown and Russell. Hence, their findings are not contradicted by our experiments. Although these observers were inclined to disregard the role of the labyrinth in concussion, they presented no evidence in favor of their conclusion. If, in mild head traumas, acceleration is an important factor, and in severe head traumas labyrinthine function is lost, the inference is that the labyrinth may play a greater role in closed head injury than heretofore suspected. Crucial experiments must be devised to determine the actual role of the labyrinth in concussion.

#### SUMMARY

1. A method of producing a severe type of standardized closed head injury in the dog with blasting caps is described.

2. Surviving dogs presented a uniform neurologic syndrome. In the first days, this was characterized by somnolence, inability to stand, ataxia, and salivation. Permanent disability consisted of inability to jump, tendency toward circle walking, absence of postrotatory nystagmus, and impaired labyrinthine-righting reflexes.

3. The gross necropsy findings of the brains in all animals showed a lack of uniformity, indicating that the hemorrhages present were not responsible for either death or the neurologic syndrome. In some animals no hemorrhages were found. Small hemorrhages into the brain stem were found in half of the brains.

4. The evidence suggests that the disturbance uniformly produced by the blasting cap was due to damage to the labyrinths.

#### REPRESENTATIVE PROTOCOLS

##### *Immediate Deaths.*—

PROTOCOL I.—Dog 426. Male. 12.2 kg.

5/1/42. 8:42 A.M. Ether administered for four minutes. One cap taped over right parietal region.

8:48. Cap fired. Respiration stopped. Chest in inspiratory apnea. Pup dilated and fixed. Tendon reflexes absent. Artificial respiration started.

8:50. Pulse 126. Still apneic.

8:51. Pulse 168.

8:58. Heart sounds no longer audible.

5/1/42. Necropsy: Viscera normal. Tympanic membranes intact. Right temporal muscle and scalp lacerated. Skull intact. There was a thin layer of blood over the entire right hemisphere and the posterior part of the left hemisphere. No hemorrhages in the brain.

PROTOCOL II.—Dog 960. Male. 13.4 kg.

6/15/42. One cap taped to external occipital protuberance.

2:34 P.M. Cap fired. Thrown violently to the floor. Respiration ceased, all reflexes absent. Artificial respiration started.

2:40 Pulse over 200.

2:42. Dead.

6/15/42. Necropsy: Visceral normal. Tympanic membranes intact. Scalp lacerated. Temporal muscle normal. Skull intact. Slight amount of subarachnoid blood. The brain appeared normal except for moderate congestion of the veins. Cross section showed nothing abnormal except for moderate enlargement of both lateral ventricles from the middle of the ventricle backward extending downward into the inferior horn. The left ventricle was larger than the right. In the pons there were several minor and one major hemorrhage into the basal part.

#### *Postponed Deaths.—*

PROTOCOL III.—Dog 113. Male. 6.8 kg.

6/17/42. One cap taped over right zygoma.

2:33 P.M. Cap fired. Thrown to the floor. Apneic. Pupils dilated and fixed. Corneal reflex absent. Artificial respiration started.

2:42. Breathing spontaneously, very shallow, 12 per minute. Pulse 12. Corneal, patellar, and withdrawal reflexes still absent.

2:46. Pulse 12. Respirations 9. Pupils fixed. Corneal reflex sluggish. Patellar and withdrawal reflexes present. Limbs flaccid.

2:51. Occasional blinking. Pulse 7. Respirations 8, very shallow.

2:56. Pads of limbs cold. Respirations 4.

2:58. Artificial respiration resumed. Pulse 10.

3:03. Pulse 10.

3:06. Pulse 36.

3:09. Animal dead.

6/17/42. Necropsy: The right temporal scalp was lacerated. The temporal fascia was intact and the muscle was not injured. There were no fractures. There was a slight amount of blood in the subarachnoid space over the hemispheres. The surface of the brain was entirely normal except for possible bruising of the right flocculus. Cross section failed to reveal any pathology except for the very slight superficial lesion of the right flocculus.

PROTOCOL IV.—Dog 468. Male. 16.6 kg.

6/16/42. 11:08 A.M. Ether for five minutes. One cap taped to external occipital protuberance.

11:15. Cap fired. Respiration stopped for 40 seconds. Corneal reflex absent for one and one-half minutes. Pulse 39.

11:29. Respiration 38, rapid and shallow. Pulse 39. Forelimbs slightly rigid. Tendency to opisthotonos. Unable to stand, or even to raise head. Pupils moderately wide, reacted normally to light. Patellar and withdrawal reflexes present.

1:00 P.M. Lays motionless on side. All limbs flaccid. Salivation profuse. Corneal reflexes absent. Pupils fixed. Pulse 82. Respiration 10, very shallow.

the clinical symptoms, both early and late, could be attributed to sudden cessation of function of these organs with partial or complete recovery. It is conceivable that concussion may result from widespread inhibition of the central nervous system acting through a reflex, possibly originating in the labyrinths. This theory is supported by investigations dealing with the role of head acceleration in experimental head trauma. Denny-Brown and Russell<sup>3</sup> found that "concussion" ensued when the degree of trauma applied to the freely movable head reached a critical acceleration of 28 feet per second. When the head was fixed, far greater forces were necessary to produce "concussion." We have estimated the head acceleration of our dogs, by means of rapid cinematographic films taken at the time of the explosion, to be in the neighborhood of 64 feet per second. Under these experimental conditions, fixation of the head did not alter the results. The trauma produced by the blasting caps was obviously of much greater force than that reported by Denny-Brown and Russell. Hence, their findings are not contradicted by our experiments. Although these observers were inclined to disregard the role of the labyrinth in concussion, they presented no evidence in favor of their conclusion. If, in mild head traumas, acceleration is an important factor, and in severe head traumas labyrinthine function is lost, the inference is that the labyrinth may play a greater role in closed head injury than heretofore suspected. Crucial experiments must be devised to determine the actual role of the labyrinth in concussion.

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about 1 cm. in diameter, but extending to a minor degree to the medial, as well as the posterior margin of the hemisphere. There was some minor hemorrhage at the basal surface of the brain at the angle of the entering right eighth nerve. The pin at the base of the brain overlying the chiasmatic cistern was opaque and slightly thickened. On cross section, small hemorrhages, the size of a pin point, were found within a distance of 1 mm. of each other in the medial aspect of the left third temporal convolution and the bordering lateral aspect of the basal longitudinal gyrus at the level of the ascending fornix. There were two other bleedings of the same small size in the left hemisphere, one below the left anterior commissure and the other in the middle of the corpus striatum. There were larger hemorrhages in the middle of the left temporal lobe bordering the hippocampus and a fresher focus, possibly a thrombosis, at the same level in the left internal capsule. There was a bilateral, slight but definite enlargement of the lateral ventricles. Sections through the occipital hemorrhage showed the involvement of the cortex as expected. A brown discoloration was seen in the entering root of the right eighth nerve. No other gross lesion was found in the brain stem.

PROTOCOL VI.—Dog 478. Female. 9.2 kg.

5/7/42. Ether for four minutes. One cap taped to the external occipital protuberance.

1:24 P.M. Cap fired. Apnea for 60 seconds, respiration resumed a few compressions of chest.

1:26. Whining, raised head. Pupils dilated, reacted sluggishly.

1:37. Attempted to stand, fell. Lying on belly with limbs sprawled and head upright. Tossed head from side to side. Head tremor.

1:58. Crawled a few steps on flexed limbs.

3:37. Asleep. No response to loud noise. When grasped, eyes opened, animal righted itself spontaneously and crawled a few steps.

5/11. Able to stand for a brief interval. Fell on the attempt to walk.

5/13. Unchanged.

5/14. Walked hesitantly on broad base staggering noticeably. Responded to call. Walked in circles mostly to the left, at times to the right.

5/18. More active. Gait improved. Still walked drunkenly, slipping and falling at times.

5/20. Gait unchanged. Walked in circles, mostly to the left, at times to the right. In jumping from a height of one and one-half feet, fell clumsily. Placing and hopping reactions normal. Tonic neck and body reflexes normal. Labyrinthine righting reflex absent. No postrotatory nystagmus.

5/22. Necropsy: Viscera normal. Scalp healed. Skull intact. Meninges normal. Symmetric subpial hemorrhages about 1 cm. in diameter covered the outer surface of the two occipital lobes. On frontal sections a small area was suspected of being a softening at the level of the descending fornix in the lateral angle of the internal capsule and the temporal lobe. The lateral ventricles were slightly enlarged. The right lateral ventricle was, in its posterior part, a trifle larger than the left. In the medulla oblongata, a hemorrhage the size of a pinhead was located at the level of the entering vestibular nerves in the midline, 2 mm. below the ventricular surface and in or immediately below the posterior longitudinal fasciculus.

PROTOCOL VII.—Dog 428. Male. 18.8 kg.

5/6/42. Ether for six minutes. One cap taped to the external occipital protuberance.

8:02 A.M. Cap fired. Respirations stopped 40 seconds. Resumed spontaneously.

8:09. Lying motionless. Limbs flaccid. Pupils wide, reacted sluggishly. Withdrawal, patellar, and corneal reflexes present.

8:15. Blinking. Profuse salivation.

8:20. Raised head. Rolled onto crouched limbs. Attempted to stand, fell heavily. Repeated efforts several times in rapid succession with increasing violence. At times leaped fully a foot from the floor. Panting heavily. Glaring, tossing head from side to side. Seemed confused. Head tremor.

9:30. Lying on left flank, head between forepaws, eyes closed. Drooling profusely. No response to noise. When touched, eyes opened. Placed on feet, resumed violent movements in an attempt to stand.

12:06. Quiet for the most part. Occasional attempts to stand. Could crawl on flexed limbs.

3:00 P.M. Ataxic attempts to stand could be elicited by placing dog on feet. The intensity of the movements were diminishing.

5:00. When placed on limbs, fell limply. Ataxic movements no longer could be elicited.

5/7. Little activity. Nodding head tremor still present to minor degree. When placed in upright position stood on a broad base, did not attempt to walk, but lay down after a few moments. With hindlimbs held, could walk on forelimbs; able to stand on hindlimbs with tendency to give way in one or the other limb. In supine position, with head extended, all limbs extended headward; with head flexed, limbs relaxed. Rotation of body followed by head rotation; turning head followed by twisting of body.

5/8. Definitely better. Walked drunkenly and soon fell.

5/10. Walked the length of the room, slowly, hesitantly on a broad base.

5/13. Unchanged.

5/15. More active. Walked on broad base, swaying drunkenly at times. Responded to call. Shudder ended in tail flip; at times this movement threw the animal to the floor. Walked in circles to the left. Refused to jump from height of two feet, preferring to remain on table. When pushed, fell clumsily.

5/20. Extremely restless. When out of cage, walked about continuously, stopping only for a moment or two to scratch or to shudder. Circle movements to the left were frequent. Unable to jump without falling. Labyrinthine-righting reflexes and postrotatory nystagmus absent.

5/25. Sacrificed. Viscera normal. Ear drums normal. Skull intact. Dura normal. The surface of the brain showed nothing abnormal, nor did frontal sections, with one questionable exception at the level of the red nucleus. The surface here seemed to be sprinkled with enlarged blood vessels or small hemorrhages in the brain stem, while the region of the elaustrum was somewhat reddish.

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#### REFERENCES

1. O'Connell, J. E. A.: A Group of Head Injuries, *Lancet* 2: 719, 1941.
2. Cloward, R. B.: War Injuries to the Head, *J. A. M. A.* 118: 267, 1942.
3. Denny-Brown, D., and Russell, W. R.: Experimental Cerebral Concussion, *Brain* 64: 93, 1941.
4. Webster, J. E., and Freeman, N. E.: Studies on the Cerebrospinal Fluid Pressure in Unanesthetized Dogs, *Ann. Surg.* 113: 556, 1941.
5. Cannon, W. B.: Cerebral Pressure Following Trauma, *Am. J. Physiol.* 6: 91, 1901.
6. Lindquist, J. L., and LeRoy, G. V.: Studies of Cerebral Oxygen Consumption Following Experimental Head Injury, *Surg., Gynec. & Obst.* 75: 28, 1942.
7. Jakob, A.: Experimentelle Untersuchungen über die traumatischen Schädigungen des Zentralnervensystems (mit besonderer Berücksichtigung der *Commotio cerebri* und *Kommotionsneurose*), in *Nissl-Alzheimer's histologische u. histopathologische Arbeiten über die Grosshirnrinde*, vol. 5, Jena, 1912, p. 182.

8. Pilleker, C.: Experimental Cerebral Trauma; the Fluid Content of the Brain After Trauma to the Head, *Arch. Surg.* 35: 512, 1937.
9. Duret, H.: *Études expérimentales et cliniques sur les traumatismes cérébraux*, Paris, 1878, p. 101.
10. Rademaker, G. G. J.: *Das Stehen*, Berlin, 1931, Julius Springer.
11. Canis, M.: *The Physiology of the Vestibular Apparatus*, translated by R. S. Creed, New York, 1930, Oxford University Press.
12. Dow, R. S.: The Effects of Unilateral and Bilateral Labyrinthectomy in Monkey, Baboon, and Chimpanzee, *Am. J. Physiol.* 121: 392, 1938.
13. Linthicum, F. H., and Rand, C. W.: Neuro-otological Observations in Concussion of the Brain, *Arch. Otolaryng.* 13: 785, 1931.
14. Brünner, H.: Pathologie und Klinik der Erkrankungen des Inner-Ohres nach Stumpfschädeltraumen, *Monatschr. f. Ohrenh.* 59: 697, 763, 922, 1925.
15. Russell, W. R.: Injury to Cranial Nerves Including the Optic Nerves and Chiasma, in *Injuries of the Skull, Brain and Spinal Cord*, edited by S. Brock, Baltimore, 1940, Williams & Wilkins Company, p. 120.

## A CASE OF INFECTION WITH CLOSTRIDIUM SORDELLII AND A CASE OF GAS GANGRENE TREATED BY PENICILLIN

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TWO cases of mixed infections with anaerobic microorganisms are reported because of certain features of interest attached to them. The first patient was infected by *Clostridium sordellii* and *Clostridium welchii* and was treated with penicillin. The second developed gas gangrene of the abdominal wall following an operation on the biliary tract. A third case mentioned is so similar to the second that the two may supply a syndrome of this unusual complication. The second patient was treated with penicillin and polyvalent antiserum, the third received no specific treatment. Although all three patients died, no general conclusion can be drawn from them concerning the efficacy of penicillin in similar infections. Many cases will have to be collected, treated at various periods in the course of their infection, and with various methods of administration, before evaluation of penicillin therapy can be made. Because these cases are relatively rare and because no one sees many of them, they are put on record.

CASE 1.—A 30-year-old American born Negro woman had been treated in the outpatient clinic for asthma and recurring head colds which were thought to be allergic in origin. Two days before admission to the hospital, because of an asthmatic attack she received from a doctor on the outside a hypodermic injection of adrenalin, morphine, and atropine in the back of the left arm. The following day she was aware of swelling and tenderness in the region of the injection. These symptoms increased, and she became feverish. Shortly before admission to the hospital she noted rapid increase of the rate of swelling and she experienced periods of great prostration. The significant physical findings, treatment and course were as follows.

May 31, 1943, the patient was admitted at 8:30 P.M., appearing ill. Rectal temperature was 102.6° F.; pulse, 76; respirations, 20. There was great swelling of the left upper extremity from the upper deltoid region almost to the elbow. The swelling extended around the upper arm so that it had to be held away from the body, and also involved the axilla. It was so tense that it suggested to the first doctor who saw her the possible need for releasing incisions through the deep fascia. There was some tenderness in the swollen area, most marked on the medial and axillary aspects. The lack of redness and heat was striking. There was no fluctuation. The radial pulse was difficult to feel at either wrist because her blood pressure remained low, at times being almost unobtainable. Urine showed albumin 3 plus. The blood count was white blood cells, 30,750; polymorphonuclears, 86 per cent (0-17-69); lymphocytes, 11 per cent; monocytes, 1 per cent; eosinophiles, 2 per cent.

Treatment that night consisted of high elevation of the arm, poultices to the upper arm, sulfadiazine 1 Gm. every four hours with soda bicarbonate 0.5 Gm.,

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amytal 0.1 Gm. repeated once, codeine, 0.06 Gm. and aspirin 0.6 Gm. repeated twice. She slept fitfully, complaining of pain in the swollen area, and generalized itching. At times she seemed to be irrational.

June 1, 8 A.M., the temperature was 99.8° F.; pulse, 96; respirations, 22. The swelling of the arm had extended throughout the forearm to the wrist. The blood pressure was hardly obtainable, although the patient was clear mentally. The medical consultant thought that the swelling could not be explained upon an allergic basis. X-ray of the arm showed no gas in the tissues. There were still no signs of a focus of infection. The sulfadiazine was stopped after she had received 3 Gm. in twelve hours.

*Operation.*—Incision 10 cm. in length under local novocain anesthesia in the posterior aspect of the arm, where the hypodermic injection had been given which was the probable source of the infection. The subcutaneous tissues were extremely firm and grayish yellow in color. Clear watery fluid exuded when the tissues were divided. There was practically no bleeding. The patient went into shock just before the operation. The tissues were divided through the brachialis fascia without encountering pus or gas. The underlying muscle appeared normal. The wound was tamponed open with China silk.

Pathologic examination of a specimen of the subcutaneous tissue was later reported to show scattered small foci of lymphoid infiltration, but nothing suggestive of acute inflammation. Culture of a specimen of the subcutaneous fat showed no growth, but *Cl. welchii* and *Cl. sordellii* appeared next day from swabs moistened in the wound at the same time. There was no aerobic growth.

Eight hundred cubic centimeters of pooled plasma and 700 c.c. of saline solution were given by infusion about the time of the operation.

The swelling of the arm increased in spite of profuse discharge of serous fluid from the incision. An hematocrit taken shortly before midnight was 37.8, plasma specific gravity 1.0217, plasma protein 5.03. The blood in the tube was hemolyzed.

June 2, 12:30 A.M., further multiple incisions through the deep fascia were made into the area of swelling, because of the extreme tension of the tissues. Her blood pressure was at this time unobtainable. Pulse was about 100. Five hundred cubic centimeters of whole blood were given. A generalized urticaria followed. At 3 A.M. 300 c.c. of plasma were given, without reaction. Pulse during the night remained at about 80 to 88. Temperature went to 102.4° F. but at 8 A.M. was 100°. Hematocrit at this time was 73.7, plasma specific gravity 1.0223, plasma protein 5.24. The blood sample was hemolyzed. Blood count was red blood cells, 6,950,000; hemoglobin, 19.4 Gm. (134 per cent); white blood cells, 34,650; polymorphonuclears, 94 per cent (1-47-46), lymphocytes, 5 per cent; monocytes, 1 per cent. At 12:30 P.M. 500 c.c. of plasma and 500 c.c. of saline solution were given by infusion. At 1:30 P.M. soon after microorganisms resembling *Cl. welchii* were reported in the culture from the wound, 50,000 units of sodium penicillin were given intramuscularly. At 2:45 P.M. 50,000 more units of penicillin were given intravenously, and this was repeated at 4 P.M., and again at 9:45 P.M. At 3:45 P.M. hematocrit was 75 and plasma protein 3.92. At 9:15 P.M. she received 500 c.c. of plasma. The total fluid intake during this day was 6,050 c.c. and urine amounted to 350 c.c. There was much serous discharge from the wounds. Late in the day the patient's temperature rose to 102.6° F. at which time her pulse was 80 and her blood pressure unobtainable. At 11 P.M. hematocrit had fallen to 67.5 and plasma protein had risen to 4.52.

June 3, 1943, at 1 A.M., she received 350 c.c. of plasma containing 50,000 units of penicillin, and two hours later 300 c.c. of plasma. Her pulse about this time dropped below 60. She seemed quite alert but not wholly oriented. Ten thousand units of penicillin were given intramuscularly at 4 A.M., 7 A.M., and 10 A.M. Blood count, taken about 9 A.M., was red blood cells 7,550,000; hemoglobin 22.2 Gm.

(153 per cent); white blood cells 58,200; polyphonuclears 84 per cent (1-44-39), lymphocytes 16 per cent. Her temperature rose during the morning to 104.8° F. It was about this high at the time of death at 11:15 A.M. She had recognized her sister one-half hour before.

Post-mortem examination revealed the following significant abnormal findings: swelling and edema of the subcutaneous tissues of the left upper extremity with extension into the left side of the thorax and neck. In one region of the left pectoralis muscle there were many areas of necrosis and hemorrhage. There were 200 c.c. of clear yellow fluid in the peritoneal cavity, 250 c.c. in the right pleural cavity, and 750 c.c. in the left, with partial atelectasis of both lower lobes. Microscopic sections of the subcutaneous fat of the left arm showed edema, many small hemorrhages, perivascular accumulations of polymorphonuclear leucocytes which were undergoing degeneration, and a pale homogeneous coagulum within the walls and the lumens of some of the vessels. Gram-positive and gram-negative rods were observed in one area. *Cl. sordellii* and *Cl. welchii* were grown from the operative wounds and the latter also from the pectoral muscle, subcutaneous fat, and the right ureter.

The course of this patient's infection was rapid and little affected by treatment. Approximately twelve hours after receiving the fatal injection, she noticed swelling. Within forty-eight hours of the injection, she came to the hospital. The swelling at that time extended from upper deltoid to elbow, was very marked where it existed, and had well-defined borders. The nature of her condition was not at first recognized, and there was even some doubt whether she had an infection or an allergic reaction because of the absence of redness and heat in the swollen area, the intermittent and low grade of fever, and the slow pulse. The x-ray showed no gas in the swollen tissues.

Within sixty hours after admission to the hospital, or approximately four and one-half days after receiving the injection, she was dead. During her course in the hospital, the striking features were the enormous local swelling, the intermittent and finally constant state of hypotension, the relatively slow pulse and absence of high fever, and the progressive and extreme hemoconcentration. Treatment during the sixty hours in the hospital included 3 Gm. of sulfadiazine during the first twelve hours, not enough to be a test of the efficacy of the drug, 2,750 c.c. of plasma and 500 c.c. of whole blood during the last forty-three hours of life, and 280,000 units of penicillin intravenously and intramuscularly during the last seventeen hours of life. She received no specific antiserum because the *Cl. sordellii* were not recognized either by the clinical picture or by the laboratory during her life.

No clear effect on the progress of her infection was observed as a result of this therapy and only temporary and relatively minor effects on the course of her hemoconcentration. Although *Cl. welchii* was grown from various parts of the body, the case was clinically predominately one of infection with *Cl. sordellii*. Reference is made to the cases described by Meleney, Humphreys, and Carp,<sup>1</sup> in which the characteristic features were the tremendous woody edema which spread with more or less rapidity from the focus of infection, the absence of

pus or gas when the tissues were incised, the presence of hard white subcutaneous fat from which there was a copious discharge of serous fluid, the prostration, and the fatal outcome. Studies of blood concentration were not included in that report. Infections of laboratory animals show that the microorganism characteristically does not grow in great numbers in the tissues nor spread very widely, but produces the edema and toxemia by diffusion of its toxin. There is little evidence of death of tissue even at the focus.

The only treatment at present known is large doses of polyvalent serum which includes principles of antisordellii toxin. Supportive measures are also necessary and possibly releasing incisions. The prognosis is bad, but might be better if early diagnosis were made. This would be possible only if the doctor in charge of the case had the condition in mind and recognized the clinical picture. By the time that *Cl. sordellii* is isolated from the lesion and identified, the infection may well have been fatal.

CASE 2.—A 50-year-old Finnish woman came to the hospital complaining of attacks of pain in the right upper quadrant, associated on occasions with chills, fever, and jaundice. Her past history was remarkable only for two partial thyroidectomies for nontoxic goiter. Physical examination revealed nothing unusual except the scar in the front of her neck, and a diastolic cardiac murmur. She stated that she habitually climbed four flights of stairs without dyspnea. There were no abnormal laboratory findings. A cholecystogram revealed no evidence of a gall bladder shadow. On July 7, 1943, she was operated on with a diagnosis of chronic cholecystitis, cholelithiasis with stone in the common duct. A right subcostal incision was made, dividing the right rectus muscle and part of the lateral oblique muscles. There were many adhesions in the right upper quadrant; no gall bladder was recognized, but there was a calculus measuring 3 by 1 cm. in the common duct. After the calculus was removed, a probe could be readily passed into the duodenum and into both hepatic ducts. The ducts were thoroughly irrigated with saline solution. The bile in the common duct was muddy, and was subsequently shown to contain *Cl. welchii*, *Bacillus coli*, and *Streptococcus viridans*. There was no evidence of an acute inflammatory process. Exploration of the abdomen revealed no other abnormality. The appendix was removed, a T tube was fastened into the common duct and a soft rubber drain placed alongside it, and the wound was closed about the drains in layers, by means of interrupted silk sutures.

For twenty hours the postoperative course was not thought to be unusual, except that the patient could not void and had to be catheterized. During the morning of the first postoperative day, however, it was noticed that the patient was lethargic, that there was a good deal of serous discharge from the wound, and that bloody drainage was coming from the rubber tube, although bile was coming from the T tube. There was also found to be a hard, painful, tender area above the wound extending up toward the breasts. All this was apparent less than twenty-four hours after operation. Pulse by noon had risen to 130 and temperature to 103.6. When the wound was dressed, the amount of discharge was noted to be excessive, but the odor was not thought to suggest anaerobic infection. There was an area extending up from the wound which was swollen, hard, tender, and quite sharply outlined, corresponding roughly to the extent of the upper portion of the right rectus muscle. The lower margin of the wound was not affected. The wound was opened, but it was not until some sutures were taken out of the anterior sheath

exposing the muscle that a little gas was seen bubbling up. A smear taken of the exposed muscle showed gram-positive rods which looked like *Cl. welchii*, and later were proved to be. (*Bacillus aerogenes* and a nonhemolytic streptococcus were also cultured from the wound.) An x-ray of the wound area taken on the way to the operating room did not reveal gas in the tissues.

The second operation was done about thirty-three hours after the first, and consisted of removal of the portion of the rectus muscle cephalad to the original wound. It was almost completely destroyed by gas gangrene, but no other area of invasion was recognized. The procedure took thirty minutes. The wound was packed wide open with zinc peroxide. Before this procedure, hematocrit was 44, plasma specific gravity 1.0264, plasma protein 6.63. Blood count was red blood cells, 4,620,000; hemoglobin, 12.5 Grams (81 per cent); white blood cells, 30,500; polymorphonuclears, 86 per cent (0-38-48); lymphocytes, 13 per cent; basophiles, 1 per cent. Before operation 50,000 units of penicillin were given intravenously, and 25,000 units at three-hour intervals until the patient died, a total of 175,000 units in sixteen hours. Starting about three hours after the second operation, she received polyvalent gas gangrene serum intravenously as follows: 60 c.c. at 1:15 A.M., 30 c.c. at 6 A.M., 60 c.c. at 10 A.M., 11 A.M., 1 P.M., 2:15 P.M., a total of 330 c.c. in thirteen hours. She also received 500 c.c. of plasma about the time of the second operation, 1,000 c.c. of saline solution by clysis shortly before the operation and 4,000 c.c. of 5 per cent dextrose in saline solution by vein during the night following operation. On the morning of July 9, ten hours following the second operation, venous pressure was 100 mm. and hematocrit, plasma specific gravity, and plasma protein essentially the same as they had been the day before. One liter of urine was collected by catheterization. Her temperature during the night fell dramatically from 106.6° F. shortly before midnight to 99.4° at 8 A.M. It did not again rise. Her pulse meanwhile fell from 130 before operation to 100 the next day, where it remained almost until she died. Nevertheless, her blood pressure fell, breathing became wheezy, and she began to cough after the second injection of anti-toxin and for that reason only half the dose was given. Subsequent doses of antitoxin did not have this effect, but breathing remained somewhat difficult and moist, and she became jaundiced. In spite of the drop in temperature and pulse, she looked more ill. She died at 3:40 P.M., fifty-two hours after the first operation.

At autopsy, virtually no evidence of active infection was found. No *Cl. welchii* were grown from cultures of the wound. The patient did have edema of the glottis and some edema of the lungs, and also a rheumatic heart with a rather tight mitral stenosis. The jaundice was unexplained. It was not due to persisting anaerobic infection, but may have been the result of the period of toxemia. The presence of bile plugs in the canaliculi suggested a factor of obstruction, but no cause of obstruction was found. The liver was not apparently the site of an infection. Incidentally, no gall bladder was found.

It would appear that the gas gangrene infection had been controlled, which might have been the result of any or all of the therapeutic measures taken, that is, the surgical removal of the focus, the zinc peroxide, the penicillin, and the serum. The patient's death might have been caused by any of a number of factors, such as the period of toxemia, too much intravenous fluid (although the hematocrit remained within normal limits), failure of a rheumatic heart, serum sensitivity, or edema of the glottis. It was probably a death due not directly to gas gangrene, but indirectly to it and to the chain of events which accompanied it.



CASE 3.—This case is briefly mentioned because of the similarity to Case 2. The patient was a 66-year-old woman who underwent cholecystectomy for acute cholecystitis. The incision was made transversely below the right costal margin, dividing the right rectus and part of the oblique muscles. The common duct was not explored because the woman had never been jaundiced. A rubber tube drain was placed along the bed of the gall bladder, and the wound closed around the drain in layers by means of interrupted silk sutures. Thirty-six hours after operation she complained of abdominal pain, and her temperature rose suddenly to 104° F. although her pulse at that time was only 106. Later it rose to 120. Respirations also went up to 28 and became grunting in character. Her condition was attributed to bronchopneumonia, which indeed she had, and the gas gangrene of the abdominal wall was not recognized until shortly before her death, which occurred sixty-two hours after operation and twenty-four hours after the sudden rise in temperature.

At autopsy, the gas gangrene was found to involve much of the abdominal wall below the incision. The time of onset shortly after operation, the rapid rise in temperature, the prostration and lethargy, the limitation of the infection to one edge of the wound, and the rapidly fatal outcome, were alike in Cases 2 and 3. The nature of the infection in Case 3 was not recognized in time to try penicillin or serum.

#### REFERENCES

1. Meleney, F. L., Humphreys, F. B., and Cupp, L.: An Unusual Fatal Operative Wound Infection Yielding a Pathogenic Anaerobe of the Gas Gangrene Group not Hitherto Described, *Surg., Gynec. & Obst.* 45: 775, 1927.
2. Hall, I. C., and Scott, J. P.: *Bacillus Sordellii*, a Cause of Malignant Edema in Man, *J. Infect. Dis.* 41: 329, 1927.
3. Humphreys, F. B., and Meleney, F. L.: The Identity of *Cl. Oedematoides* and *B. Sordellii*, *Proc. Soc. Exper. Biol. & Med.* 25: 611, 1928.
4. Hall, I. C.: The Occurrence of *B. Sordellii* in Icterohemoglobinuria of Cattle in Nevada, *J. Infect. Dis.* 45: 156, 1929.
5. Hall, I. C., and Gray, S. H.: Septic Peritonitis in Man Due to *B. Sordellii*, *Arch. Path.* 12: 246, 1931.
6. Hall, I. C., and Scott, A. L.: The Serologic Agglutination of *Bacillus Sordellii* and *Clostridium Oedematoides*, *J. Bact.* 22: 375, 1931.
7. Meleney, F. L.: Zinc Peroxide in Surgical Infections, *S. Clin. North America* 16: 691, 1936.

## AN ACCESSORY OPERATING TABLE FOR ORAL SURGERY ON INFANTS AND CHILDREN

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AFTER a limited personal experience in oral surgery and observations elsewhere, it seemed that the disposition of the patient undergoing cleft lip and palate repair, the arrangement of the surgeon, assistants, and anesthetist at the operating table, left much to be desired. The practice of placing the head of the patient on the knees of the surgeon or allowing it to hang over the edge of the table is not conducive to the maintenance of an adequate airway, to the stability of the operative field, or to the proper drainage and aspiration of blood, mucus, or excess ether vapor. With these points in mind a device was designed and built, and has been in use for the past eight years. The materials are all common, obtainable, and can be assembled by the hospital carpenter. While not in use, the accessory table can be folded and easily stored.

When the operating room is set up, the hinged boards are placed on the table and fastenings applied to the lower board. These may be either trunk straps or knee straps which are used to hold adult patients to the operating table. The patient is then placed on the working surface, which is the upper board, and fastened into position with the trunk straps. After anesthesia is established the patient is then raised into the position, which is sufficiently vertical to allow proper drainage from the mouth. This corresponds to Rose's position in which blood and mucus may flow over the incisor teeth. The anesthetist may insert a small ether hook into the month, or an intranasal tube, and administer the anesthetic from an attached machine. The drapes are arranged and a stitch of silk placed in the tongue and fastened to the topmost sheet, thus holding the tongue out of the field. The operator is then ready to proceed. The photographs are self-explanatory.

*Specifications.*—The working model of the table now in use is made of wood which has been treated with a suitable coating of white enamel. It might be possible to reproduce this table with thin sheets of stainless steel, Monel metal, or cast aluminum with some saving of weight although the table as now constructed is easily handled. Overall dimensions of the boards are 42 by 18 by  $\frac{7}{8}$  inches. They are hinged together at one end with two standard hinges. The top board, or work-

ing surface, carries the slots and straps and the hinged support on its back. The lower board which is strapped to any operating table carries the slotted angle irons which support the working surface when the rods are placed in position.

The working surface provides six slots parallel to each other, 6, 5 and 3 inches in length and all  $\frac{1}{2}$  inch wide. The two slots at the top of the board are  $\frac{1}{2}$  inch long and 2 inches wide. The lowest slots are 4 inches long and 2 inches wide. The straps used are ordinary 6 foot

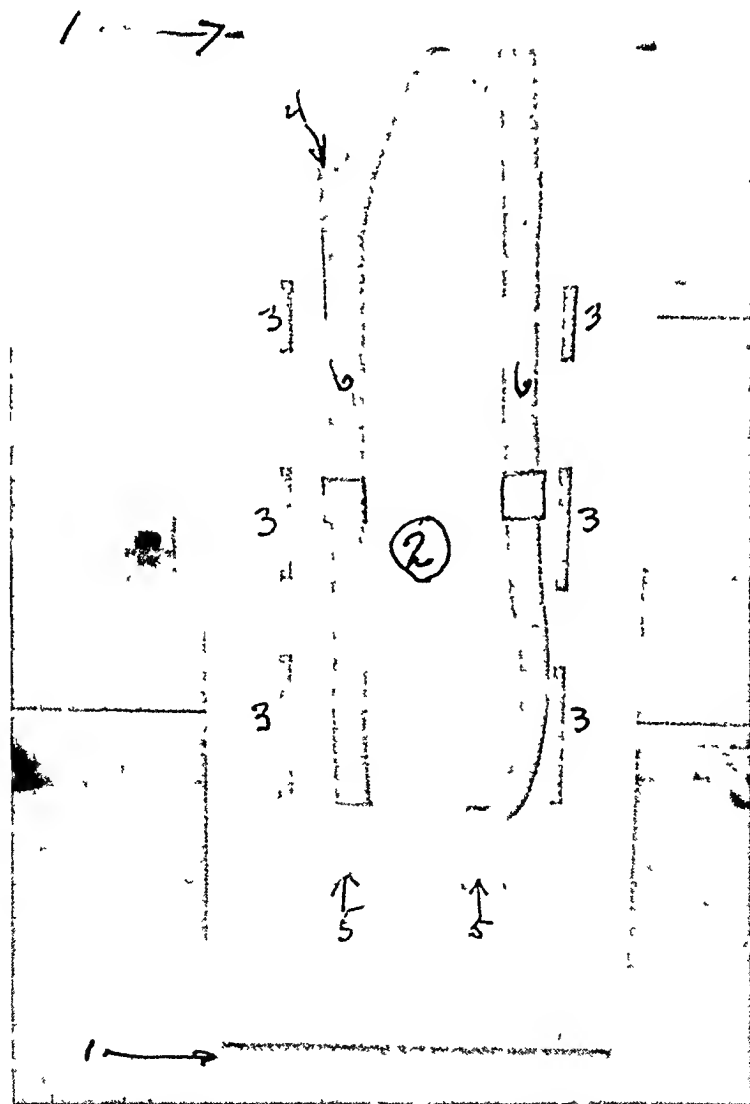


Fig. 1.—The working model stands on the floor resting against a common instrument table for the purpose of comparison of sizes. Shown here are six slots arranged in pairs (3) and four paired slots (4 and 5) arranged above and below (3). There are also metal gliders (1) and trunk straps (6) shown on the upper surface upon which the patient is placed (2).

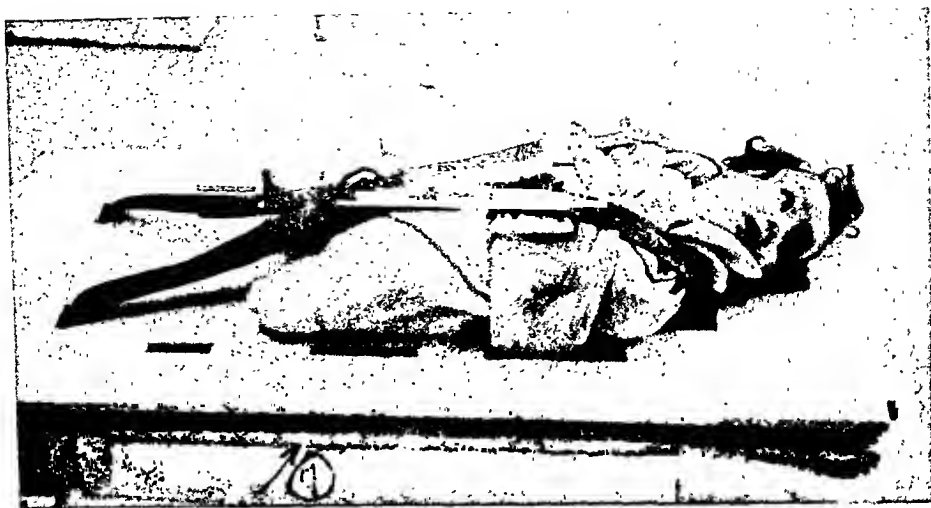


Fig. 2.—A patient has been placed on the accessory table after it has been fixed to the lower table by two web straps (7). Note the use of the narrow slots for fixation of the patient by means of a wide band and the crossing of the trunk straps over the shoulders for use of suspension in the vertical position (8).

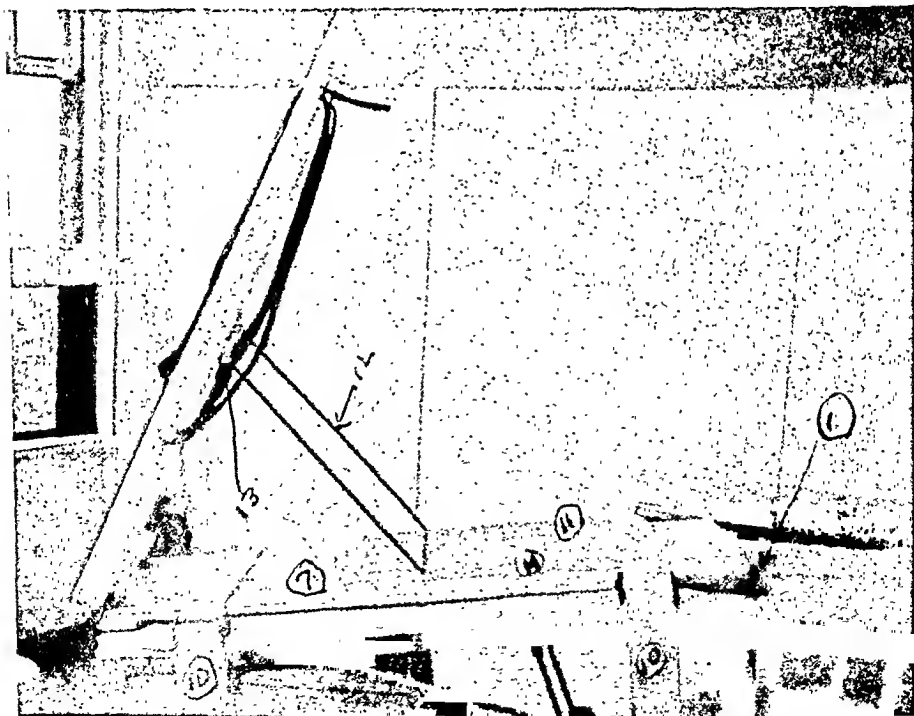


Fig. 3.—Side view of hinge (9), web knee straps (10) and angle iron (11) slotted to receive  $\frac{3}{4}$  inch U-shaped rod support (12). Hook-and-eye hinge (13) attached to rod support and table.

length, webbed trunk straps. Two gliding casters are placed on one end of each board. These should be at opposite ends. On the underside of the working surface are provided the hinges to which this board is attached to the lower board and also the hinged hook and eye and the rod support. The rod is bent so that it is U shaped. It is of  $\frac{3}{8}$  inch material and may be steel, bronze, or iron. On the lower board there is provided two parallel right angle iron bars, 21 inches long, each containing nine slots about 2 inches apart. Into these slots the U-shaped supports fit. The supporting rods are 15 inches long.

## ASEPTIC APPENDECTOMY—THE APPLICATION OF THE PARKER-KERR SUTURE TO THE APPENDICAL STUMP

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THE purpose of this communication is to describe in detail the application of the Parker-Kerr suture to the appendical stump, obviating the necessity of ligating the stump. Asepsis in dividing the appendix is achieved by use of the cautery.

Since the first appendix was successfully removed, there has been considerable debate concerning the ideal appendectomy. Numerous series of appendectomies have been reported with very low mortality employing ligation and inversion of the appendical stump within a purse-string suture. Other series have been reported with similar mortality rates in which the stump was simply ligated and permitted to remain unperitonized within the abdomen. The chief criticism of either method centers about the possibility of: (1) rupture of the appendical stump after appendectomy with consequent peritonitis and abscess formation; (2) bowel obstruction from adhesions of the ileum to the cecum at the site of appendectomy; (3) mucocoele formation in the stump; and (4) secondary appendicitis occurring at a later date in a stump left too long after division of the appendix.

It is felt that the method to be described successfully precludes all of these complications better than any other method. It adapts the basic principles of aseptic intestinal anastomosis to appendectomy.

### METHOD

Although the actual treatment of the appendix to be described can be used with any type of incision, it will be assumed that the operation is for appendectomy alone.

For this operation, a McBurney approach to the cecum is used. The skin incision is made in a transverse-oblique direction in the line of the skin folds, over McBurney's point. After the abdomen is opened, the cecum is mobilized, and the appendix is delivered into the wound. The mesoappendix is ligated in the usual manner, with one or more ligatures, usually of No. 1 or No. 0 plain catgut. As the mesoappendix is divided between ligatures, it is peritonized with interrupted, fine, single silk sutures while the appendix remains attached to the cecum.

The base of the appendix must be completely mobilized from all peritoneal bands connecting it to the cecum. A small straight hemostat is then placed across the base of the appendix, close to the cecum, but not including the cecum. The hemostat is set so that the handle and shaft are parallel to the ascending colon and parallel to the longitudinal tenia with the tips of the clamp pointing toward the base of the cecum.

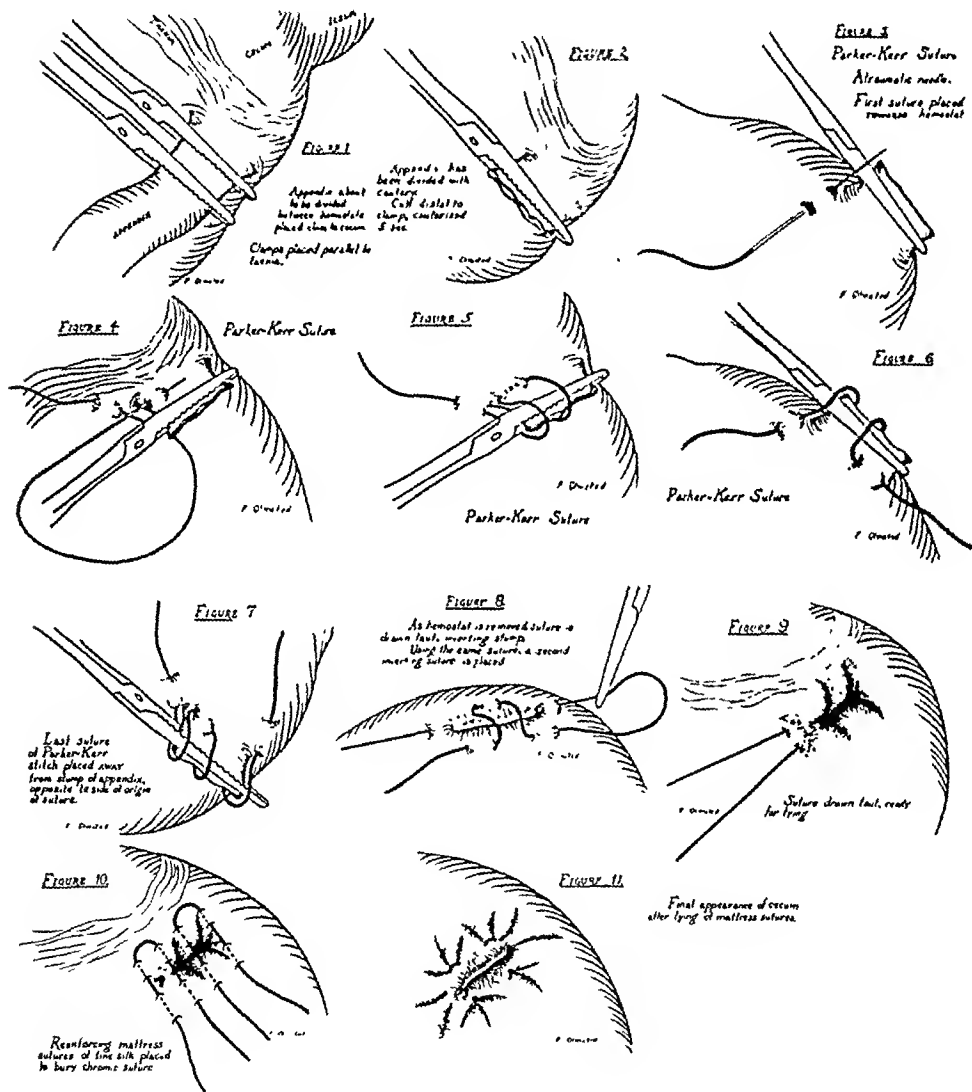


Fig. 1.

(Fig. 1). A second hemostat is set distal to the first. The appendix is divided with the actual cautery so that a cuff of appendix about 1 mm. long is left distal to the proximal clamp (Fig. 2). This cuff is further cauterized for five seconds. A Parker-Kerr suture of No. 00 chromic catgut on a weld-on needle is then placed across the clamp holding the base of the appendix (Figs. 3 to 7).

The clamp is withdrawn as the suture is tightened, inverting the stump of the appendix into the cecal lumen. With the same chromic suture, a second continuous suture is placed over the Parker-Kerr suture line (Fig. 8). The suture is then tied at the same place where it was begun (Fig. 9). Two or three mattress sutures of single intestinal silk are placed so as to cover the knot of the catgut suture and to re-enforce the remainder of the chromic suture line (Figs. 10 and 11).

#### COMMENT

Several steps of this procedure are worthy of emphasis. Care must be taken to free the appendix from the cecal wall so that the Parker-Kerr suture can be accurately placed submucosally. The hemostats applied to the appendix must be placed parallel with the longitudinal tenia so that the suture line will not encroach upon the ileocecal valve. Cauterization of the short cuff distal to the clamp holding the base of the appendix insures hemostasis and temporary sealing of the stump. The initial and final placing of the Parker-Kerr suture must be as indicated (Figs. 3 and 7) so that proper inversion of the ends of the stump will occur. The Parker-Kerr suture line must be re-enforced with interrupted nonabsorbable sutures.

#### CONCLUSION

The advantages of this method are: (1) Aseptic division of the appendix is achieved with the actual cautery. (2) The appendix is divided at the cecum so that mucocoele or appendicitis of the stump is impossible. (3) The stump of the appendix is inverted into the cecal lumen without ligation so that no blind pocket between the stump and the inverting suture is possible. (4) No unperitonized surface of the cecum is present.

Fifteen consecutive appendectomies have been performed in this fashion without complication.



## LESIONS OF THE TERMINAL COLON ASSOCIATED WITH URINARY DISTURBANCES

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IT IS obvious that patients with urinary symptoms eventually fall into the hands of urologists for diagnosis and treatment. This being the case, it naturally follows that urologists must constantly be on the alert to the ever-present possibility that many symptoms which, on the surface, appear to be due to diseases involving the genitourinary tract may actually be due to extraneous conditions. It is the purpose of this communication to deal with lesions of the terminal bowel which give rise to urinary disturbances.

*Hemorrhoids.*—Hemorrhoids constitute one of the more frequent conditions associated with prostatism, especially when prostatism is due to prostatic hypertrophy. In these cases hemorrhoids result from pressure exerted upon the hemorrhoidal plexus of veins by the enlarged gland, and from straining during urination. Patients frequently seek relief of the annoying hemorrhoids rather than of the prostatic condition to which they owe their origin. After ascertaining the absence of a lesion in the rectum or rectosigmoid responsible for the hemorrhoids, it is necessary to make careful inquiries regarding the exact status of the urinary tract. In older men special inquiries should be made to establish the condition of the prostate gland. Once it is determined that the patient has an obstructive prostate, one may be reasonably certain that measures directed to its removal will, in the vast majority of instances, lead to spontaneous amelioration or complete disappearance of the hemorrhoids. On the other hand, surgical intervention for the relief of hemorrhoids without removal of the offending prostate is certain to lead to recurrence of symptoms.

*Carcinoma of the Rectum.*—One of the most frequent sources of error in urologic diagnosis is the tendency to overlook the presence of carcinoma of the rectum, particularly among men with hypertrophy of the prostate gland. This is especially true in patients with symptoms of prostatism who, on perfunctory digital rectal examination, present grossly enlarged prostates. It is extremely tempting in such instances to indulge in a snap diagnosis of prostatic hypertrophy with its implication that the enlarged gland is the underlying and sole cause of the urinary disturbance. It must be realized, however, that the discovery of an enlarged prostate on rectal examination does not necessarily imply that the prostate is the cause of the prostatism. It is not unusual to see patients who, although disclosing enlarged prostates on

rectal digital examination, fail to show any evidence of intrusion of prostatic lobes into the urethra, or evidence of vesical neck distortion due to the enlarged prostates on cysto-urethroscopy. Visual disclosures of this character signify that the prostate plays no pertinent role in the causation of presenting genitourinary symptoms.

Urologists can readily attest to the fact that certain lesions in juxtaposition to the vesical neck, although extrinsic to the genital tract, can and do give rise to prostatism. The most frequent among such lesions is carcinoma of the rectum. It is also common knowledge that men harboring grossly enlarged prostates are prone to present symptoms referable to the lower bowel, especially the rectum. The more common symptoms are constipation, a sense of fullness in the rectum, hemorrhoids, and rectal bleeding. The collateral symptoms can readily be explained on the ground of pressure exerted by the enlarged prostate upon the rectum itself and upon the hemorrhoidal plexus of veins and nerves.

While loss of weight would tend to make one alert to the possibility of some malignant lesion, it is not at all unusual to see long-standing cases of prostatism, especially among elderly patients who have lost weight and strength solely because of an associated chronic azotemia. This same explanation holds true for secondary anemia which is frequently encountered in both conditions.

In order to avoid the danger of overlooking the presence of carcinoma of the rectum in patients presenting clear-cut histories of prostatism, it is necessary to establish definite and fixed rules in examining these patients. Of primary consideration is a carefully taken history, with special emphasis placed upon changes in bowel habits, such as constipation or diarrhea. Rectal bleeding is an extremely important symptom, even in patients suffering from large hemorrhoids.

Every prostatic should have a careful digital rectal examination instead of the perfunctory one usually performed in palpating the prostate. In view of the fact that in the vast majority of cases rectal carcinomas are situated within reach of the examining finger, and in view of the fact that in men with pronounced enlargement of the prostate it is at times difficult to examine accurately the region directly above the base of the prostate by means of the usual technique, it becomes necessary to employ methods designed to render maximum information. I have found that in order to accomplish this end, patients should be examined while lying in the supine position, with knees drawn up to the chin. The right index finger is introduced into the rectum, and the palm of the left hand exerts gentle downward pressure over the suprapubic region, while the patient is instructed to bear down. The examining finger is then carefully swept around the entire circumference of the rectum. Through this maneuver the examiner is enabled to extend the range of palpation considerably above the base

of the prostate, regardless of its size. Detection of anything suspicious warrants immediate proctoscopic examination to visualize the lesion and to obtain specimens for biopsy. Failure to palpate anything suspicious does not relieve the examiner of the responsibility of performing proctosigmoidoscopic examinations upon patients presenting evidence of bowel disturbances, regardless of how slight they might be.

Having detected the presence of a carcinoma of the rectum, it becomes necessary to ascertain its role in the causation of urinary symptoms. Careful cysto-urethroscopic examination should, in most instances, readily establish the role played by the enlarged prostate. An enlarged prostate gives rise to prostatism by interfering with the free flow of urine from the bladder by virtue of its tendency to compromise the vesical neck or prostatic urethra, or both. Regardless of its size, as determined by rectal digital examination, failure of the gland to encroach upon the prostatic urethra or vesical neck, in my opinion, definitely rules out the possibility of the prostate as playing any role in the causation of urinary symptoms. A rectal carcinoma which gives rise to urinary disturbances usually presents certain fairly characteristic cystoscopic features. The most common is a localized area of bullous edema involving a portion of the base or posterior wall of the bladder, while the remainder of the bladder wall appears relatively normal. This finding suggests a bowel lesion which has become adherent to the bladder through inflammatory adhesions or as a result of actual invasion. Occasionally one may even see, in long-standing cases, an actual communication between the bladder and rectum (rectovesical fistula). In very early cases, instead of an area of bullous edema, one may note a patch of hyperemia involving a localized area of bladder wall. A not unusual finding is a localized area of invagination of a portion of the posterior bladder wall into the vesical lumen, with no apparent change of the mucosa covering this portion of bladder.

Another problem which is occasionally encountered is a patient who presents an enlarged prostate on rectal digital examination along with a rectal carcinoma. Cystoscopy, however, discloses a well-defined median bar, but no intrusion of the prostate into the bladder or prostatic urethra.

The therapeutic problem involved in this group of cases is naturally dependent upon findings. When the prostate is enlarged and obstructing, treatment must obviously be directed to the removal of the gland. While transurethral resection is the procedure of choice, enucleation by the perineal or suprapubic routes is far more preferable under certain circumstances, particularly when associated with renal insufficiency. Following relief of the prostatic obstruction, appropriate therapy should be instituted to remove the rectal lesion as quickly as is compatible with safety. However, should cystoscopy fail to disclose any causal relationship between the physical characteristics of the prostate and the presenting urinary symptoms, surgical intervention

should be directed to the eradication of the rectal carcinoma without giving any consideration to the gland. Urinary symptoms in this group of cases usually disappear spontaneously following the removal of the rectal carcinoma.

*Lesions of the Sigmoid and Rectosigmoid.*—

*Diverticulitis of the Sigmoid:* Acute or chronic diverticulitis of the sigmoid frequently results in adhesions binding the affected segment of the sigmoid to a portion of the posterior wall of the bladder. This condition inevitably results in urinary symptoms closely simulating prostatism. In fact, the urinary symptoms may be so prominent as to overshadow completely any symptoms referable to the colon, so that in many instances patients will consult the urologist rather than the intestinal surgeon for relief of symptoms. Careful cystoscopic study of the bladder usually discloses a localized area of congestion or bullous edema of the posterior vesical wall, and in severe and long-standing cases may reveal the opening of a sinus tract connecting both viscera. Such lesions often simulate neoplasms so closely that it is difficult to differentiate between the two conditions without the aid of biopsies. Detection of this condition, in the course of a routine cystoscopic study warrants careful interrogation of the patient regarding bowel habits. As usually happens, patients falling within this group are stocky in build and present histories of long-standing episodes characterized by pain in the left loin associated with constipation or diarrhea, with or without bouts of fever. While passage of blood in the stool may be present, it is not as commonly encountered in cases of diverticulitis as in cases of carcinoma of the bowel. Hematuria is not an unusual symptom. Correct diagnosis can always be established by means of proctoscopy and double contrast barium enemas.

Although acute diverticulitis often subsides under appropriate conservative medical care, it is very doubtful whether anything short of surgery will suffice to bring relief in cases associated with adhesions between the involved colon and the vesical wall. In such cases the logical procedure is to set the involved segment of bowel completely at rest by means of a "defunctioning" colostomy placed at some distance proximal to the sigmoid, preferably in the transverse colon. A colostomy of this type, in order to be effective, should be permitted to function for from nine to twelve months. If, at the expiration of this time, it is determined by x-ray and sigmoidoscopy that the process is still active, the affected segment of bowel should be extirpated and the continuity of the bowel restored. If it has been ascertained that in addition to the diverticulitis, an obstructing prostate is also present, measures should be taken to remove the prostate, preferably by transurethral resection whenever practical. Prostatectomy should be performed prior to the establishment of colostomy when the obstruction is marked. In

the milder types of obstruction, it is better to wait one or two months after the affected segment of bowel has been defunctioned, before resorting to prostatectomy.

*Carcinoma of the Sigmoid and Rectosigmoid:* Malignant tumors involving the sigmoid and rectosigmoid give rise to urinary symptoms as a result of pressure upon the bladder, or of direct involvement of the vesical wall by carcinomatous infiltration, or by inflammation. Pressure manifestations usually occur in cases where the tumor is of fairly large size and located in the mobile portion of a redundant sigmoid flexure, in which case the tumor drops down deeply into the pelvis between the rectum and bladder. In these cases cystoscopy reveals an invagination of a segment of posterior bladder wall into the vesical lumen without any evident change in the mucosa over the site of the intrusion.

Urinary symptoms are elicited more frequently in cases where tumors have become adherent to segments of bladder wall by carcinomatous infiltration or by inflammatory adhesions. Such tumors are more apt to be found in the lower third of the rectosigmoid. It is not an infrequent occurrence to find an abscess present in the depth of the pelvis due to an old perforation of the bowel at the site of the tumor. When this occurs, vesical symptoms are often well pronounced.

Since patients falling within this group are more likely to consult the urologist before the abdominal surgeon, it is necessary for him to be constantly on the alert if he is to avoid grave errors in diagnosis. It is well known that tumors involving the left half of the colon are notorious for their tendency to occlude the bowel. Because of this fact, it is imperative to interrogate patients carefully concerning changes in bowel habits, regardless of the fact that the primary complaint may apparently be concerned with the urogenital tract. Since lesions in this segment of bowel are also prone to bleed, a history of bleeding from the rectum assumes added significance, and should never be passed over lightly as being due to hemorrhoids which frequently accompany prostatism. Excessive loss of weight, especially when accompanied by asthenia, is suggestive of this type of lesion, particularly in the absence of azotemia or carcinomatous changes within the prostate gland. The merest suspicion of malignancy warrants prompt sigmoidoscopy and barium enema studies to elicit the diagnosis.

The same principles of therapy apply here as in the conditions previously discussed. When the intestinal lesion is the sole cause of urinary disturbances, the indicated procedure is to eradicate the lesion in the bowel. If, however, lesions involving both the colon and the bladder or prostate are present, it is my belief, that the latter should have priority; and the treatment should be so designed as to provide prompt relief of the urinary conditions, with the least manipulative efforts. Suprapubic cystostomy should always be performed where actual or

threatened perforation or fistula formation between the colon and bladder exists. This procedure need in no way interfere with the surgical approach to the intestinal tumor. In fact, suprapubic cystostomy is often of inestimable value in the surgical management of cases of intestinal carcinomas, particularly when lesions are situated low in the bowel and require considerable manipulation of the bladder and its sympathetic nerve supply in the course of the operative procedure.

#### CASE REPORTS

**CASE 1.**—M. P., aged 47 years, was seen June 23, 1940, complaining of increased diurnal and nocturnal urinary frequency, dribbling, and difficulty in starting the stream, associated with belching and pyrosis. Fifteen years before he had had a gastrectomy performed for ulcer. Rectal examination disclosed internal hemorrhoids, fissure, and fistula in ano. Following hemorrhoidectomy along with the excision of the fissure and fistula, he made an uneventful recovery with complete disappearance of all urinary symptoms.

**CASE 2.**—J. B., aged 61 years, seen Sept. 23, 1930, complained of increased diurnal and nocturnal urinary frequency, dribbling, pain on defecation, and bleeding from the rectum. Proctoscopic examination disclosed a fissure in ano with hemorrhoids, for which surgery was performed. Following this he made an uneventful recovery, with complete disappearance of all urinary symptoms.

*Comment.*—Cases 1 and 2 both illustrate prostatism due entirely to spasm of the muscles about the vesical neck which resulted from irritative lesions of the rectum and anus. Appropriate treatment directed to these causes led to complete relief of symptoms.

**CASE 3.**—J. D., aged 60 years, was seen Feb. 2, 1943, complaining of retention of urine, dribbling, and frequency of urination, of several weeks' duration. There was occasional constipation, but no bleeding from the rectum.

Investigation of the genitourinary tract revealed an enormous enlargement of the prostate. Kidneys were normal.

*Physical examination.*—Blood pressure was 140/90; heart and lungs, normal. There were large thrombosed hemorrhoids. By rectum the prostate felt enormously enlarged and irregular.

Following a two-stage suprapubic prostatectomy, all symptoms including those due to the hemorrhoids disappeared.

**CASE 4.**—J. H., aged 66 years, was seen Aug. 18, 1943, complaining of prostatism and lack of appetite with belching, abdominal distention, and constipation of a few years' duration.

*Diagnosis.*—Median bar, chronic cholecystitis, and internal hemorrhoids. Cholecystectomy and appendectomy were performed. During convalescence he suffered an attack of prolapsed thrombosed hemorrhoids, with pain and bleeding on defecation. Following transurethral resection urinary symptoms disappeared, and the hemorrhoids receded.

*Comment.*—Cases 3 and 4 are examples of hemorrhoids associated with prostatic disease which subsided spontaneously following prostatectomy.

**CASE 5.**—S. R., aged 64 years, was admitted to the hospital on the night of April 28, 1941, with an attack of acute urinary retention. He stated that for

the past few months he was troubled with diurnal and nocturnal urinary frequency. During this period he had lost twenty-five pounds in weight. Only after careful questioning was it ascertained that he had occasional bouts of diarrhea alternating with periods of constipation.

Physical examination disclosed a thin, cachectic, chronically ill patient who presented no outstanding signs. Blood pressure was 170/90. The prostate, as felt per rectum, did not appear particularly enlarged or hard.

Cystoscopy disclosed marked contracture of the vesical neck, with a well-defined median bar. The lateral lobes were not enlarged. On the anterior wall of the bladder near the vault there was a small area where the mucosa appeared reddened and edematous. This finding led us to believe that we might be dealing with a contact inflammation resulting from some intra-abdominal lesion lying adjacent to the bladder. It was fairly certain that the genitourinary findings did not fully explain the presenting clinical picture, particularly the general cachectic appearance of the patient, and the complete urinary retention.

Sigmoidoscopy disclosed a tumor involving the anterior wall of the rectum, situated 4.5 inches from the anus. Biopsy showed adenocarcinoma of the rectum.

Exploratory laparotomy, performed May 13, 1941, revealed a large mass about the size of an orange involving the sigmoid flexure, upper rectum, one loop of small intestine, and the posterior vesical wall. A metastatic nodule was present in the right lobe of the liver. A loop colostomy was performed above the tumor. Following this, all urinary symptoms disappeared, indicating thereby that the urinary retention was primarily due to spasm rather than to mechanical obstruction of the vesical neck by the prostate gland.

CASE 6.—S. McI., aged 59 years, was first seen July 14, 1930, complaining of increased diurnal and nocturnal urinary frequency, dribbling, difficulty in starting the stream, and pyuria, of eight months' duration.

The physical examination was essentially negative. On rectal examination the prostate felt small and elastic.

Cystoscopy disclosed a thickened, trabeculated bladder with a well-defined median bar and contracture of the vesical neck. The lateral lobes of the prostate were not involved.

July 29, 1930, the bar was excised with the Collings electrotome, and the patient was discharged from the hospital August 1. He returned Oct. 3, 1930, and stated that since leaving the hospital he had noticed rectal irritability which had become more pronounced during the preceding five days. Two months previously he had noted blood in the stool, which persisted for two days but did not recur. There was no diarrhea, constipation, or loss of weight. Digital rectal examination revealed a hard, annular carcinoma involving most of the anterior wall of the rectum, just barely palpable to the examining finger.

The symptoms of prostatism presented by this patient were undoubtedly due to spasm induced by the carcinoma of the rectum, which had been overlooked at the time of his first examination.

CASE 7.—H. K., aged 58 years, was seen May 7, 1928, complaining of difficulty in urinating, frequency of urination, and dysuria. On rectal examination an ulcerating carcinoma was found involving the lower anterior wall of the rectum. The prostate was not enlarged.

CASE 8.—A. F., aged 59 years, was seen June 18, 1943, complaining of pain in the left lower abdomen, bleeding from the rectum, painful defecation, increasing constipation, and frequency of urination, voiding six times during the day and one to two times at night, and slight dysuria.

*Physical examination.*—Blood pressure was 140/90. There was tenderness of the left lower abdomen. Proctoscopy revealed bleeding internal hemorrhoids. Sigmoidoscopy was negative. Barium enema showed a well-filled colon, with no evident defect.

The patient was seen at the office on several occasions where the hemorrhoids were touched up with silver nitrate. Pain persisted, however, and operation was advised and accepted.

At operation an infiltrating carcinoma of the sigmoid flexure was found, consisting of a mass about the size of an orange infiltrating into the bladder.

CASE 9.—J. B., aged 53 years, was seen Oct. 14, 1943, complaining of right renal colic of one week's duration, frequency of urination, voiding six times during the day and two to three times at night, pain in the right lower abdomen, and dull right lumbar pain. Stools were normal; there was no constipation.

*Physical examination.*—Blood pressure was 130/80. There was right costovertebral tenderness and tenderness and rigidity over the entire abdomen. Rectal examination was negative, rectal temperature 103.2° F.; pulse, 100.

He was immediately hospitalized and prepared for operation, at which time a ruptured tumor of the sigmoid and generalized peritonitis were found. A Mikulicz resection of the bowel was performed. Pathologic diagnosis was diverticulosis of sigmoid; acute purulent diverticulitis of sigmoid with intramural abscess formation and fibrinopurulent perisigmoiditis; appendix showing mild acute serosal inflammation.

CASE 10.—M. N., aged 52 years, was seen April 11, 1943, complaining of pain in the epigastrium and left lower quadrant on and off for several weeks, bleeding from rectum, occasional attacks of diarrhea alternating with constipation, loss of weight, frequency of urination, and occasional dysuria.

Physical examination revealed a well developed man, who appeared ill. Blood pressure was 130/90. There was tenderness present in the left iliac fossa. Rectal examination was negative.

Fluoroscopy of the colon with barium enema showed the column of barium reaching up to the region of the rectosigmoid, beyond which no barium could be seen. The patient complained of a great deal of distress, making it impossible to allow more barium to enter the bowel.

X-rays of the colon showed the ampulla very much dilated. There was a jagged deformity of the lower rectosigmoid, with several diverticula.

Sigmoidoscopy failed to reveal any lesion as far as the sigmoidoscope could be introduced, which was a distance of 7 inches.

*Blood Count*—Hemoglobin, 108 per cent; red blood cells 5,760,000; white blood cells, 16,400, polymorphonuclears, 70 per cent; lymphocytes, 16 per cent; rods, 6 per cent; metamyelocytes, 1 per cent; monocytes, 7 per cent.

*Urinalysis.*—Specific gravity, 1.021; pH, 5.7; albumin and sugar, negative; microscopic occasional white blood cells; few epithelial cells and mucus.

The patient was admitted to the hospital on the morning of April 13, 1943, complaining of pain in the lower abdomen, and temperature of 102° F., and presenting signs of peritonitis. He was prepared for immediate laparotomy.

At operation the rectosigmoid just above the peritoneal reflexion presented a large mass (diverticulum) about the size of an adult fist adherent to the promontory of the sacrum behind, extending over to the right of the midline and adherent to the right iliac fossa and to the bladder in front. The right lateral margin of this mass was covered with fibromucopurulent exudate. There was an escape of free pus from the peritoneal cavity. A double-barrel colostomy was performed.



The patient made an uneventful recovery, and was discharged from the hospital, May 9, 1913, with a well-functioning colostomy. All urinary symptoms had disappeared.

CASE 11.—M. S., aged 16 years, was seen Oct. 18, 1938, complaining of abdominal cramps following defecation, ribbonlike stools, occasional nausea and vomiting, and frequency of urination, voiding seven to eight times during the day and once at night.

*Physical examination.*—Blood pressure was 130/80. There was a definite tender mass situated in the left iliac fossa, which was fairly well fixed. Rectal examination was negative.

Sigmoidoscopy was negative.

Barium enema x-rays revealed marked spasticity of the sigmoid colon, with pocketing just above the sigmoidal loop. After evacuation, barium remained behind in this loop.

The patient was sent to the hospital where a "dysfunctioning" colostomy was performed for diverticulitis of the sigmoid flexure. Convalescence was uneventful, and he was discharged nineteen days later. All urinary symptoms had disappeared.

He was seen at the office two months later, when a barium enema revealed no evident defect in the colon, as previously noted. There was no recurrence of urinary disturbance. April 27, 1939, he was again sent to the hospital where the colostomy was closed.

#### SUMMARY AND CONCLUSIONS

This communication deals with certain lesions of the terminal colon which give rise to urinary symptoms suggesting involvement of the urogenital tract. It emphasizes the fact that prostatism may be due solely to involvement of this segment of the bowel or in combination with obstructive hypertrophic prostates. When prostatism is primarily the result of lesions in the terminal colon it can be attributed to spasm of the vesical neck resulting from irritation of the anterior rectal wall. Histories taken from patients presenting urinary symptoms must include precise and careful interrogation regarding bowel habits. Carefully performed rectal examination is imperative in all urologic patients, especially prostatitis. Whenever symptoms suggest the possibility of rectal or anal involvement, digital examination should be supplemented by proctoscopic and x-ray studies of the colon. In the presence of symptoms suggesting colonic irritation, when preoperative examinations have failed to reveal evidence of colonic pathology, it is essential to perform careful rectal examination following the removal of the obstructing prostate. Appropriate treatment of an obstructing prostate should take precedence unless intestinal symptoms strongly predominate. A series of cases is presented to illustrate the various phases of this problem.

## A NEW TECHNIQUE FOR REPAIR OF FACIAL PARALYSIS WITH TANTALUM WIRE

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IT HAS been suggested by J. C. White† that tantalum wire be used for repair of facial paralysis, rather than fascial strips. A new technique has been devised at The Walter Reed General Hospital for the treatment of facial paralysis.

The method is simple and effective, and stabilizes the mouth, lower end of nose, and eyelids, thereby transmitting some elements of expression to the paralyzed side. There are certain advantages when this technique is employed:

1. The operation is performed under local anesthesia.
2. No disability or bed rest is necessary for the patient, as no incision is made for the removal of fascia from the thigh.
3. When the wires are in position, the patient can sit up and the wires can be tightened to the proper tension, thereby doing away with the amount of sagging in the paralyzed side which occurs when patient is lying down.
4. There is no swelling or hemorrhage in the tissues of the paralyzed side because of the very slight trauma which is produced by the small caliber of the local needle.
5. This method can also be used to hold the muscles in balance during the time the nerve is regenerating, and when fully recovered the wires can be removed.

### TECHNIQUE

Only tantalum wire .007 gauge, long local needle 18 gauge, and clips made from tantalum foil .025 thick are used. The clips are cut one-half inch long, one-fourth inch wide, and have a hole punched in each end; the square corners are rounded and then folded onto themselves over the tip of a small mosquito forceps (Fig. 1).

The temporal region is shaved and thoroughly prepared. A hockey stick incision about one and one-half inches long is made above the zygoma over the temporal muscle in the hair-bearing area, in order to hide the scar in the hair. The temporal fascia is exposed. A long curved 18 gauge needle is then inserted into the incision, passing downward between skin and mucosa, injecting novocain  $\frac{1}{2}$  per cent to just lateral to the midline on the normal side of the upper lip. The needle is then brought close to the surface and a small wheal of local anesthesia

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Fig. 1.—Tantalum foil molded on mosquito forceps to be placed around muscle to prevent wire from cutting through the muscle.

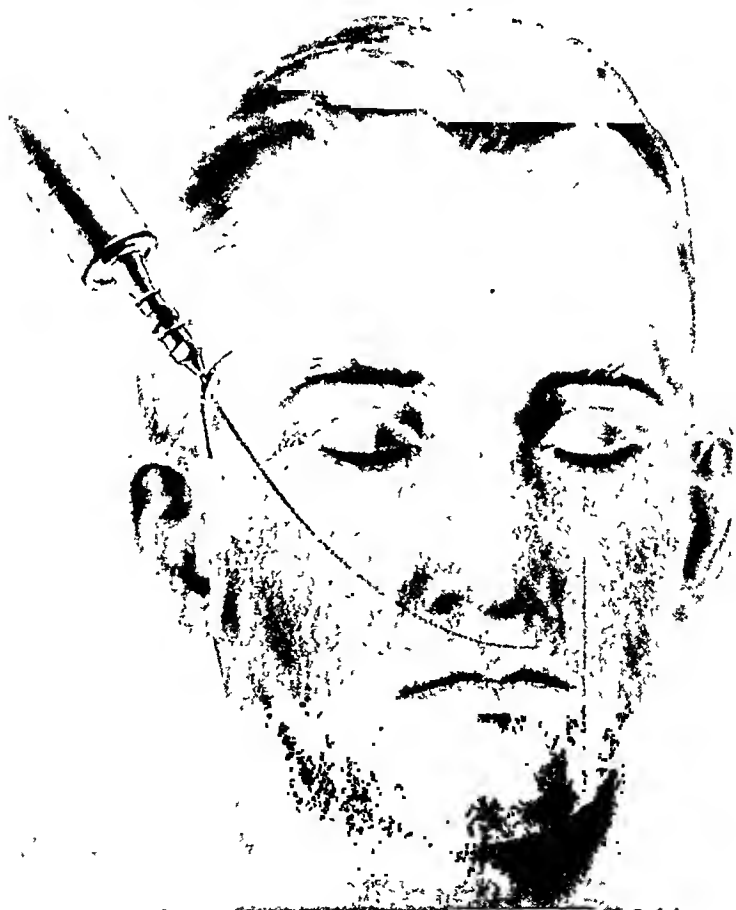


Fig. 2.—Drawing shows incision and position of fine gauge needle.

is then made. A stab incision is then made through the wheal and a bundle of muscle is tunneled by use of small scissors and mosquito forceps. The previously described clamp is then placed around the



Fig. 3.—Position of incision over tip of needle.

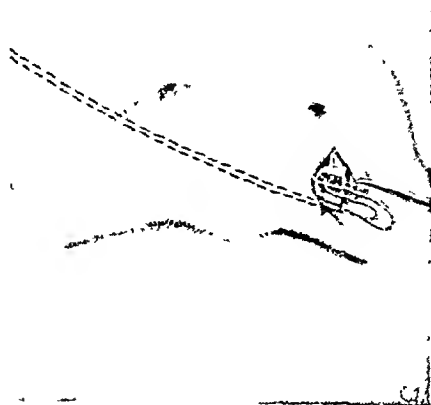


Fig. 4.—Tantalum foil around muscle with tantalum wire threaded through the local needle.

muscle bundle and the tantalum wire is passed through the holes in the clamps; the syringe is removed, the ends of the tantalum wire are passed through the bore of the local needle to the incision in the tem-

poral area, and the needle is removed. The incision in the lip is closed with fine silk or horsehair (Figs. 2, 3, and 4).

The same procedure is carried out for the angle of the mouth on the paralyzed side, and also just lateral to the midline of the normal side of the lower lip (Fig. 5).

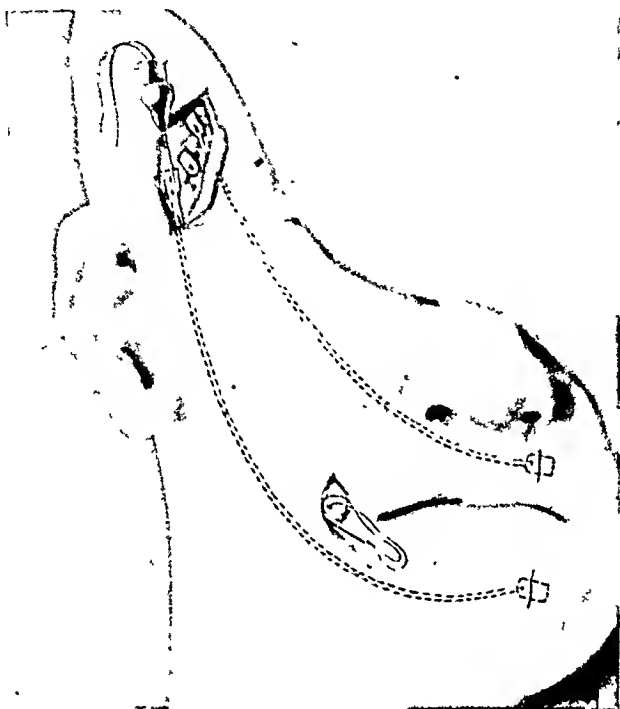


Fig. 5.—Wires in position.



Fig. 6.—Drawing of wires with protective tantalum foil attached to temporal muscle and fascia.



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Figs. 7 and 8.—X-rays demonstrating position of wires.

Small parallel incisions are made in the temporal fascia and muscle and small bundles are thus formed from the fascia and muscle to which the small tantalum clamps are fastened. The tantalum wire which has passed through the local needle into the temporal incision is reinserted



Figs. 9 and 10.—Appearance of patient before and after operation

into the small holes of the clamps. The patient is placed in a setting position and the wires tightened the required amount. The excess is cut with scissors and the end is pressed down into one of the small

parallel incisions, whereby the large primary incision is closed with fine silk or horsehair. A small sterile bandage is placed over each incision (Fig. 6).

The patient can talk, eat, and walk immediately because the large pressure bandage ordinarily employed with this procedure is eliminated. Tube feeding for a period of one week, as required when fascial strips are used, is not necessary with this technique. There is very little danger of damaging the parotid duct. The possibility of perforating the oral cavity is minimized because novocain is injected ahead of the needle.

In the case described, it was not felt necessary to anchor the muscle in the nasolabial fold or the upper or lower eyelids. However, the procedure can be carried out as previously described for the mouth (Figs. 7, 8, 9 and 10).

In this procedure it would not be necessary to remove any of the superior border of the malar bone for the passage of the tantalum wire around the upper and lower eyelids for decreasing the size of the palpebral fissure and protecting the cornea.

In cases where there is an excess of sagging skin, this can be corrected by standard plastic procedures not discussed in this communication.



## THE ASSOCIATION OF THROMBOPHLEBITIS WITH HEMATOGENOUS BONE INFECTION

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**I**N SEPTEMBER, 1941, I reported in SURGERY a case of acute hematogenous osteomyelitis of the upper end of the tibia with bacteriemia, in which the inflammatory process spread outward from the bone to involve the adjacent saphenous vein in a thrombophlebitic process, and in which control of the bacteriemia only took place after operative excision of the involved vein. At that time, I pointed out the similarity of this case to the ordinary case of mastoiditis with jugular thrombosis.

In spite of the fact that this association had occurred to me many times previously as a theoretical possibility, this was the first objective demonstration of this occurrence that I had encountered. A second similar experience has since occurred which I report herewith.

In March, 1931, the patient, then a young unmarried woman, developed a painful swelling of the middle portion of the left tibia. A biopsy showed a hemorrhagic mass in the interior of the tibia which was reported "subcutaneous inflammation." The x-ray examination showed a cavity in the medulla of the bone. The cavity was curetted out. The final diagnosis on discharge was "an inflamed bone cyst of the tibia."

In September, 1936, there was a recurrence of pain in the same area. The lesion in the tibia was again explored operatively. There were similar findings and the wound healed uneventfully.

During the succeeding several years, there were a number of exacerbations of pain and swelling in the same bone which subsided spontaneously.

In May, 1943, the patient developed a dento-alveolar infection which suppurred and was incised and drained. Almost immediately thereafter, there was another recurrence of the previous inflammatory process in the tibia. There were no chills or excessive fever or other signs of a general infection, and the condition seemed localized to the tibial area.

This time the inflammatory swelling seemed to spread outward from the tibia into the soft parts on the anterior aspect of the leg. The patient was treated with radiotherapy. As the swelling began to subside, one could distinguish very distinctly a thrombosed vein lying in the subcutaneous tissue fairly close to the anterior border of the tibia. Under continued radiotherapy, the entire condition cleared up until final healing.

It seems likely that this was a hematogenous infection from the site of the dento-alveolar infection. The association with a phlebitis in the anatomically associated vein is again striking and adds another proof to the mechanism of hematogenous bone infection, that is, osteomyelitis.

## SIMPLE TECHNIQUE FOR MULTIPLE VENIPUNCTURES

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**R**EPEATED venipunctures performed to obtain blood specimens over a period of several hours have long been a source of discomfort to the patient and often a difficult task for the house officer. The latter is particularly true in obese patients or those with few veins.

These difficulties can be easily surmounted by the use of an ordinary spinal puncture needle or bone marrow needle. The virtue of these types is the stylet, the end of which presents itself flush or flat with the beveled point of the needle, thereby eliminating the possibility of blood clotting in the lumen.

The most convenient site of introduction of the needle is a vein on the volar surface of the forearm. When inserted, it can be taped in place and does not impede motion of the arm during the test. If there are no favorable veins in this area, the antecubital site is used but this necessitates immobilization of the elbow or complete cooperation of the patient, which is easily obtained.

The needle may be inserted with the stylet in place, as in a spinal puncture, or usually it is placed on the syringe and the typical venipuncture performed. After the first blood specimen is obtained, the stylet is reinserted until time for the ensuing one. The stylet, when removed, either can be held by an assistant or placed upon sterile gauze. This procedure is repeated until all specimens are obtained.

The circulation of blood past the needle tip is adequate and normal, thereby assuring accuracy. Most satisfactory results have been obtained in a research project using this technique in Smith's kidney clearance tests.

It is probably not a good idea to inject dye, such as bromsulfalein, because of possibility of contamination of the needle lumen and the immediately adjacent vein wall, although perhaps this source of error could be precluded by washing the system with from 5 to 10 c.c. of saline solution after administration of the dye.

This procedure has proved efficacious in the execution of such clinical pathologic tests as bromsulfalein, glucose, and galactose tolerance tests and many others requiring several blood specimens.

# Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M.D.

## THE OPERATIVE ATTACK ON ORGANIC PERIPHERAL VASCULAR DISEASE

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PEOPLE suffering from the consequences of organic disease of the peripheral arteries such as arteriosclerosis or thromboangiitis obliterans are generally believed to be beyond the reach of surgical aid with the exception of some few in the early stages of the latter disease. Our belief is an opposing one; these people can be helped, because there is in almost every case a functional spastic factor in addition to the organic one, and this spastic factor can be removed by surgery. This report tells of operations in fifty-nine patients who have been treated by lumbar sympathectomy, the majority of whom had advanced organic peripheral vascular disease. This work was started in 1939 and represents the first attempt in a reasonably large series of cases to disprove the current fallacy of not subjecting to operation patients with advanced peripheral arteriosclerosis. Our reward has been twofold: (1) preservation of many limbs and lives through the prevention of the onset or the spread of gangrene; (2) the relief of distressing pain.

It is a well-known fact that there are certain functional disorders of the nervous mechanism of the blood vessels causing either a vasoconstriction or a vasodilatation and that the disorders causing vasoconstriction can be dramatically relieved by surgical removal of the sympathetic nerve fibers involved. The disease which probably represents the purest type of abnormal vasoconstriction is that described by Raynaud in 1862, characterized by local asphyxia and symmetrical gangrene of the extremities. Since in this disease the peripheral blood vessels are normal except for spasm, sympathectomy gives immediate relief.

What is not generally appreciated, however, is that many of the organic diseases of blood vessels have an associated vasomotor spasm which may be the cumulative factor responsible for the ensuing gangrene. The death of the part affected is due many times not to the original arterial

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disease but to the superimposed constriction of accompanying smaller vessels. Recognition of this fact and subsequent operative removal of the nervous mechanism causing the vasoconstriction will in proper cases result in the curing of pain and the actual salvation of the part from death from gangrene. It seems almost incredible that in the presence of advanced organic arterial disease the circulation of the part supplied by these vessels can be effectively aided by any operative interference. We cannot heal the first of the factors responsible for the gangrene or the threat of gangrene, the disease of the arterial coats, but we can relieve the second factor responsible, the vasomotor spasm of the neighboring smaller vessels.

A dogmatic classification of peripheral vascular disease from the clinical and pathologic point of view is routinely given in any comprehensive discussion of the subject, but it is important to bear in mind that many patients will not fall into one of the well-differentiated and generally accepted classifications but will present findings characteristic of more than one. A close study of Raynaud's original description, for instance, shows that some of his cases were organic rather than functional in origin. A useful classification is that given by Brown and Henderson.

#### CLINICAL CLASSIFICATION OF ARTERIAL VASCULAR DISEASE

Functional or vasomotor types	Local distribution	Vasoconstricting types	1. Multiple phase color reaction: Raynaud's disease
			2. One phase color reaction; acrocyanosis, dead finger, local syncope Erythromelalgia
	General distribution	Vasodilating types	Primary or essential hypertension, early stages
			Primary or essential hypotension
Organic types	Local distribution		1. Arteriosclerosis, with or without thrombosis; diabetic gangrene
			2. Thromboangitis obliterans (Buerger's disease)
			3. Simple thrombosis or embolism
			4. Arteritis of known infectious origin (rheumatic syphilitic)
			5. Aneurysm with or without thrombosis
	General distribution	Arterio-sclerosis	1. Primary
			2. Secondary to hypertension

The functional vasoconstricting lesions of local distribution in this list are known to be improved following sympathectomy. Even certain types of functional vasoconstricting lesions of general distribution are relieved by sympathectomy. The great organic group, however, is not generally supposed to be susceptible to the sympathetic approach. Our present study concerns this latter group of organic types of peripheral arteriovascular disease; attacks on it are now being made not

frontally by attempting to alter organic changes already present in the vessels, but by a flanking movement of stopping the accompanying vasoconstriction by removing the sympathetic control. The old hopeless attitude of palliative treatment to local ischemic lesions and of passive acquiescence in frequent amputations of the toes, feet, or legs no longer is justified.

The correct differentiation of the vascular disturbances of the extremities must be made in each patient. It is of great importance to know why an ulcer is present on a toe, why the feet are cool or pale, why they sweat, why there are muscular pains in the legs, why the leg is more comfortable in a dependent position. The most important single step in the examination, the *sine qua non* of the differential diagnosis, is the search for pulsation in all palpable arteries. The role played by vasomotor contraction must next be determined by one or several of various tests. Since the nerve path for vasomotor contraction and for sweating is the same—over the sympathetic nerves arising from the first thoracic to the second lumbar spinal nerves—these tests are all dependent on the relative increase in blood flow and decrease in sweating of the involved extremity following release of vasomotor contraction.

Warming the rest of the body generally or warming extremities other than those to be tested by application of warm blankets or by immersion in hot water will through reflex inhibition of the tone of the vasoconstrictor center, cause dilatation of the vessels in the involved extremity and a consequent rise in temperature and computable blood flow if vasomotor spasm has been an appreciable factor in the disease of the extremity. These same effects may be produced by interrupting the vasomotor control of the extremity either by novocain injection of the sympathetic ganglia or by intrathecal injection (spinal anesthesia). A favorable local result is evidenced by a rise in temperature, a more healthy, rosy color to the skin, an absence of sweating, and a subsidence of pain. Fine determination of these results can be made by various calorimetric, oscillographic, and plethysmographic records.

If by such tests a diseased extremity shows definite circulatory improvement, a sympathectomy must be considered seriously. However, if the tests are not followed by improvement, it is generally believed that this operation would prove futile, but the latter conclusion is not justified. It has been our experience that a splendid result may follow sympathectomy in some patients whose preoperative tests gave no promising indications. Case 4 and Case 58 illustrate this point. Case 58 was of a man of 36 years, with an arterial occlusion of the vessels in the lower right leg, who showed no increase in temperature after reflex warming. Nevertheless, sympathectomy relieved all pain immediately, permitted elevation of the leg in any position without pain, and was followed by rapid healing of an ulcer of the heel of many months' duration. This man showed a symptom, common to many with this trouble, of less pain

TABLE I  
ARTERIOSCLEROSIS

NO	NAM†	SEX	COLOR	AGE	COMPLAINT	ADDITIONAL DIAGNOSES	PULSATION IN PEDAL ARTERIES LEGS	OPERATION	SIDE	DATE	RESULT
4	J B	M	W	57	Threatened gangrene left foot, intermittent claudication left leg		Left 0 Right, slight	Lumbar sym- pathectomy	Left	10/ 3/41	Greatly improved
5	W B	M	B	47	Gangrene foot, right	Arteriosclerosis general- ized, gangrene toe, al- coholic neuritis	No record	Lumbar sym- pathectomy	Left	9/12/39	Improved
6	W B	M	W	67	Intermittent claudica- tion, burning pain in foot; ulcer, toe left foot	Arteriosclerosis general ized, diabetes, mild, ulcer, foot, left	Left, slight Right 0	Lumbar sym- pathectomy	Left Right	3/13/40 3/28/40	Greatly improved
19	J G	M	W	57	Cellulitis; gangrene, right foot	Arteriosclerosis general ized; gangrene, feet, bilateral	Left 0 Right 0	Lumbar sym- pathectomy	Right Left	7/10/40 11/19/40	Not im- proved
23	B J	M	B	51	Pain left foot, small area gangrene, left great toe	Arteriosclerosis general ized, syphilis (Wassei- mann), amputation leg, right, old	Left, slight	Lumbar sym- pathectomy	Left	12/20/39	Greatly improved
24	K K	F	W	65	Severe pain, right foot, ulcer, right ankle	Arteriosclerosis general ized, ulcer, leg, right	Left 0 Right 0	Lumbar sym- pathectomy	Right	6/ 5/40	Greatly improved
25	J K	M	W	57	Intermittent claudica- tion, severe pain right foot and an- kle, ulcers right an- kle	Thrombo-sis, arteries, leg, right	Left, slight Right 0	Lumbar sym- pathectomy	Right	7/26/41	Greatly improved
26	H L	M	W	64	Ulcers and pain both feet	Myocarditis, osteomyeli- tis, phalanges, feet	No record	Lumbar sym- pathectomy	Left Right	9/20/40 9/28/40	Greatly improved

28	C M.	M	W	60	Intermittent claudication; gangrene, fourth toe, right foot	Arteriosclerosis generalized; gangrene, toe	Left 0 Right 0	Lumbar sympathectomy	Left Right	8/30/39 10/ 6/39	Died
31	J. M.	M	W	54	Intermittent claudication						
34	P. N.	M	W	57	Intermittent claudication	Arteriosclerosis generalized; varicose veins, legs, bilateral	Left 0 Right 0	Lumbar sympathectomy	Left	3/12/40	Improved
35	C. N.	M	W	57	Intermittent claudication	Arteriosclerosis generalized; gangrene, foot, left; amputation, leg, right, old	Left, slight Right, slight	Lumbar sympathectomy	Right	10/ 7/42	Improved
38	J. P.	M	W	63	Pain, right foot; gangrene, right foot	Arteriosclerosis generalized; hemiplegia, left, old; hypertension, gangrene, foot, right	Left 0 Right 0	Lumbar sympathectomy	Left	6/18/40	Not improved
40	H. R.	M	W	67	Intermittent claudication; gangrene, right foot						
41	K. R.	M	W	67	Intermittent claudication		Left 0 Right 0	Lumbar sympathectomy	Right	12/15/39	Died
42	M. S.	F	W	46	Cellulitis and gangrene	Diabetes; gangrene, foot, right	Left 0 Right 0	Lumbar sympathectomy	Right	7/ 9/40	Improved
44	C. S.	M	W	65	Pain, left leg; ulcers, left leg	Arteriosclerosis, generalized	Left 0 Right 0	Lumbar sympathectomy	Left	7/19/40	Improved
45	J. S.	M	W	62	Pain, right leg and foot; ulcer, right great toe	Arteriosclerosis, generalized	Left 0 Right 0	Lumbar sympathectomy	Right	2/ 9/40	Improved
48	H. S.	M	W	74	Intermittent claudication	Arteriosclerosis generalized; diabetes, mild; gangrene, foot, right	Left 0 Right 0	Lumbar sympathectomy	Left	8/30/41	Improved
						Arteriosclerosis generalized; amputation, leg, right, old	Left 0	Lumbar sympathectomy	Right	3/ 7/40	Not improved
									Left	5/16/40	
									Left	10/14/40	Greatly improved

TABLE 1—Cont'd

NO.	NAME	SEX	COLOR	AGE	COMPLAINT	ADDITIONAL DIAGNOSES	PULSATION IN PEDAL ARTERIES LEGS	OPERATION	SIDE	DATE	RESULT
51	A. T.	M	W	59	Pain, right leg and foot	Arteriosclerosis generalized; hemiplegia, right; thrombosis, arteries, lower leg, right	Left, slight Right 0	Lumbar sympathectomy	Right	5/21/40	Improved
53	G. T.	M	W	60	Gangrene, left foot	Arteriosclerosis generalized; diabetes; gangrene, foot, left	Left 0 Right 0	Lumbar sympathectomy	Left	3/27/40	Improved
55	A. W.	F	W	37	Coldness, foot, left	Diabetes; amputation, leg, right, old; gangrene, foot, left	Left 0	Lumbar sympathectomy	Left	12/ 6/39	Gently improved
57	R. W.	M	W	57	Pain in right foot and leg	Arteriosclerosis generalized; myocarditis; thrombosis, arteries, leg, lower, right	Left, slight Right 0	Lumbar sympathectomy	Right	10/22/40	Improved
17	W. G.	M	B	59	Coldness and pain in left foot	Ulcer, foot, left	Left 0 Right 0	Lumbar sympathectomy	Left	7/13/40	Died

In the group classified as Arteriosclerosis there were 24 patients, 20 males and 4 females, a ratio of 5 to 1. Two of the 4 females had diabetes and gangrene of the feet. It is interesting to observe how much more frequent is the incidence of peripheral vascular trouble in the male and that in the 4 female patients, gangrene was present only in the 2 with diabetes. There were 3 Negro patients in the group of 24, all male. The infrequent occurrence of this disease in Negroes, 1 to 8 ratio, in a hospital where the ward cases are almost equally divided between the two races, and the absence of a single case in Negro women are two additional interesting observations. The average age of these 24 patients was 58.3 years. Of the 10 patients with intermittent claudication, 5 were entirely or largely relieved of this symptom. Of the 18 patients with ulceration or gangrene, in 11 healing took place following sympathectomy, 3 had subsequent amputations, and 4 died. In the total of 24 patients, 16 showed proper-

ly no pedal pulse, 6 showed a faint unilateral pulse, 1 a faint bilateral pulse, and in 1 no record of pulsation was recorded. Following operation in 1 patient a pedal pulse appeared which was not present before operation. In 3 patients an amputation was necessary in spite of a preceding sympathectomy. Four patients had had a previous amputation of one leg before coming to us. By a prophylactic lumbar sympathectomy we were able to save the remaining leg in 3 of these 4 people. The final result showed 8 patients greatly improved, 9 improved, 3 not improved, and 4 died. These were the only deaths in our series, all four occurring in the arteriosclerosis group. The review of the histories in the cases with death, as given in detail earlier in this communication, shows that we may have been a little too ambitious at the start, but we were dealing with desperate situations. This particular group of 24 patients is the type which has heretofore almost always been considered hopeless.



with the foot in the dependent position and more pain according to the degree of elevation; he could sleep only sitting up with the foot hanging down over the side of the bed. It seems strange that the dependent foot, becoming dusky red and engorged, should grow less painful. Evidently in all positions of the extremity the arterial supply is equally poor; in the elevated position the extremity is also deprived of a large amount of its venous blood, but in the dependent position there is of course some venous stasis and even this relatively stagnant venous blood carried sufficient oxygen to be of some assistance to oxidation in the tissues and to consequent relief of pain.

The selection of patients for this operation requires the greatest care in balancing the possible benefits against the risk incurred when people in this age and morbidity group are subjected to any operation. Manifestly it would be wrong to employ this operation indiscriminately in patients suffering from diminished arterial supply to the extremities who show no evidence of improvement after preliminary tests for vasomotor spasm. Nevertheless, many patients in this group will be benefited by sympathectomy and, if their physical condition permits, should be subjected to the operation. Likewise, manifestly it is right to employ this operation in all patients suffering from the serious consequences of diminished arterial supply to the extremities, whose tests show that vasomotor spasm as well as actual organic arterial disease is a causative factor, provided the physical condition of the patient permits the operative risk.

Fortunately the operative risk is not, or should not be, great. Our rule is that in no case is a bilateral resection done at the same operation, that for the lumbar resection spinal anesthesia is by all odds the best anesthesia, and that patients whose physical condition prohibits the use of spinal anesthesia should not be subjected to this operation under any type of anesthesia.

In fifty-nine patients there were eighty-two lumbar sympathectomies (eighteen of the right side, twenty-two of the left side, and twenty-one bilateral). There were four operative deaths. The first death (Case 17) was of a Negro aged 59 years, a patient thought to have pulmonary tuberculosis, who developed a cold, painful, pulseless left foot with an ulcer on the dorsum. Lumbar sympathectomy did not benefit his foot, and he died four weeks later, autopsy showing squamous cell carcinoma of the bronchus of the left lung, gangrene of the left leg, and bronchopneumonia. The second death (Case 28) was of a white man aged 60 years, with generalized arteriosclerosis, a four-year history of intermittent claudication, and beginning gangrene of the fourth toe of the right foot. Bilateral sympathectomy, done one week apart, resulted in great improvement, but he died suddenly two weeks after the last operation with coronary thrombosis. The third death (Case 38) was of a white man 63 years of age, with generalized arteriosclerosis, a partial

TABLE II  
THROMBOANGIITIS OBLITERANS

NO.	NAME	SEX	COLOR	AGE	COMPLAINT	ADDITIONAL DIAG- NOSES	PULSATION IN PEDAL ARTERIES	OPERATION	SIDE	DATE	RESULT
1	T.A.	M	W	34	Intermittent claudica- tion; rest pain, right foot; phlebi- tis, right leg	Amputation, leg, left, old; phlebitis, leg, right	Right 0	Lumbar sym- pathectomy	Right	6/ 4/40	Greatly improved
2	M.A.	M	W	52	Intermittent claudica- tion		Left 0 Right 0	Lumbar sym- pathectomy	Right Left	1/ 2/41 2/17/41	Improved
3	C.B.	M	W	50	Intermittent claudica- tion	Hypertensive vascular disease; bronchiec- tasis, post-infec- tional	Left, slight Right, slight	Lumbar sym- pathectomy	Right	12/12/40	Improved
8	W.B.	M	W	24	Intermittent claudica- tion	Varicose veins	Left + Right +	Lumbar sym- pathectomy	Right Left	8/21/41 8/28/41	Greatly improved
10	G.C.	M	W	36	Cellulitis and phlebi- tis	Cellulitis and phlebi- tis, legs, bilateral	Left 0 Right 0	Lumbar sym- pathectomy	Right Left	7/ 7/40 7/16/40	Greatly improved
11	N.O.	M	B	31	Intermittent claudica- tion	Varicose veins, leg, left	Left 0 Right 0	Lumbar sym- pathectomy	Left	10/ 2/41	Greatly improved
14	E.D.	F	W	37	Intermittent claudica- tion; ulcer, foot, left; rest pain, foot, left		Not recorded	Lumbar sym- pathectomy	Left	6/ 9/41	Greatly improved
15	A.F.	M	B	39	Intermittent claudica- tion; gangrene, foot, left	Hypertensive vascular disease; gangrene, foot, left	Left 0 Right 0	Lumbar sym- pathectomy	Left	2/12/41	Greatly improved

16	A. F.	M	W	40	Pain, right foot	Left 0 Right 0	Lumbar sym- pathectomy	Right	9/14/40	Improved
20	A. H.	M	B	40	Intermittent claudica- tion	Left 0 Right, slight	Lumbar sym- pathectomy	Left	10/22/41 Right 10/27/41	Improved
21	L. H.	M	W	48	Intermittent claudica- tion	Left 0 Right 0	Lumbar sym- pathectomy	Right	8/26/41	Improved
27	J. L.	M	W	48	Intermittent claudica- tion	Left 0 Right 0	Lumbar sym- pathectomy	Left	10/16/40 Right 10/29/40	Improved
37	L. P.	M	B	30?	Pain and swelling in left leg and foot	Gangrene and osteo- myelitis, toes, left foot	Lumbar sym- pathectomy	Left	3/15/40	Not im- proved
43	D. S.	M	W	49	Intermittent claudica- tion		Lumbar sym- pathectomy	Right	1/25/41	Improved
54	I. V.	M	W	38	Intermittent claudica- tion; pain in hands; rest pain in left foot		Lumbar sym- pathectomy	Left	11/19/41	Improved

In the group classified as Thromboangiitis Obliterans there were 15 patients, 14 males and 1 female. Four of the 14 males were Negroes, the 1 female was white. The average age in this group was 40.2 years. Of the 12 patients with intermittent claudication, 9 were either completely or largely relieved of the complaint. Of the 4 patients with ulceration or gangrene, in 3 healing occurred following sympathectomy; the fourth required amputation in spite of sympathectomy. In the total of 15 patients, 9 showed preoperatively no pedal

pulse, 3 a faint bilateral pulse, and in 1 no record of pulsation was recorded. Following operation a pedal pulse appeared in 5 patients, which was not obtainable before operation. One patient had had a previous amputation before coming to us (Case 1). His remaining leg was gravely threatened but responded wonderfully to operation, even showing a strong pedal pulse not present before. The final result showed 6 patients greatly improved, 8 improved, 1 not improved, no deaths.

hemiplegia of six years' standing, hypertension, and pain with gangrene in the right foot. He requested operation because he had seen such improvement on two other ward patients, in spite of our advice to the contrary. Against our better judgment we consented. Because of his hypertension, 210/108, the operation was performed under ether inhalation instead of our routine spinal procedure. He developed atelectasis of the lower lobe of the right lung, which soon involved the entire lung, and he died with bronchopneumonia four days after operation. The fourth death (Case 40) was of a white man aged 63 years, with generalized arteriosclerosis, red, cold hands with loss of sensation in the finger tips, and cold pulseless feet with early gangrene of the first, third, and fourth toes of the right foot with inflammation spreading up the foot. Knowing that an amputation was imminent unless the gangrenous process could be stopped, a lumbar sympathectomy was done, Dec. 15, 1939, without avail. The gangrene continued to develop, a mid-thigh operation was done three and one-half weeks after the sympathectomy. He died several days following amputation, autopsy showing almost entire occlusion of the left anterior coronary artery, and extensive myocardial necrosis.

The operation of sympathectomy attacks the disease in several ways. Extremities with poor arterial circulation are peculiarly susceptible to cold; the colder they become the more constriction takes place in the vessels, and, since the nervous pathway for vasoconstriction and sweating is the same, the more the vessels become constricted the more sweating takes place with further lowering of temperature. This vicious cycle is broken by operation in two places; the vasoconstrictor fibers are paralyzed and sweating is abolished. In several patients an increase in the temperature of the leg and an improvement in its color were found on the side opposite to, as well as the side of, operation. This is probably due to some crossed innervation of the sympathetic fibers.

Gangrene and pain, alone or in combination, are the challenging factors in this problem. In our total of fifty-nine patients, thirty-seven (62.7 per cent) had ulceration or gangrene, while forty-six (77.8 per cent) complained of pain.

#### GANGRENE

The rapid healing of a previously indolent ulcerated or gangrenous area will often follow sympathectomy. The result in Case 4 was most gratifying, representing a type believed hopeless under the generally accepted standards of operability. The patient was a man 57 years of age, with tingling and burning pain in the pulseless left foot and cyanosis of the toes. Preliminary tests by novocain injection of the sympathetic trunk were discouraging. Following sympathectomy, the purplish toes were restored to good color, pain ceased, and the foot became warmer. Healing occurred (Case 23) in a Negro, aged 51 years,

TABLE III  
FROSTBITE GANGRENE

NO.	NAME	SEX	COLOR	AGE	COMPLAINT	ADDITIONAL DIAGNOSES	PULSATION IN PEDAL ARTERIES	OPERATION	SIDE	DATE	RESULT
7	J. B.	M	W	46	Frostbitten feet	Arteriosclerotic heart disease; gangrene, frostbite, feet, bilateral	Left + Right +	Lumbar sym- pathectomy	Left	5/ 7/40	Improved
13	O. C.	M	B	46	Frostbitten feet	Gangrene, frostbite, feet, bi- lateral; syphilis (Wasser- mann)	Left, slight Right, slight	Lumbar sym- pathectomy	Left	3/14/40	Improved
29	O. M.	M	W	57	Frostbitten feet	Myocarditis; auricular fibril- lation; gangrene, frostbite, foot, left	Not recorded	Lumbar sym- pathectomy	Left Right	5/23/39 5/25/39	Improved
32	E. M.	M	W	67	Frostbitten feet	Arteriosclerosis, generalized; gangrene, frostbite, foot, right	Left, slight Right, slight	Lumbar sym- pathectomy	Right	5/18/40	Improved
36	J. P.	M	W	64	Frostbitten feet	Arteriosclerosis, generalized; gangrene, frostbite, foot, left, old; amputation, leg, right, traumatic, old	Left 0	Lumbar sym- pathectomy	Left	4/24/40	Not im- proved
46	J. S.	M	W	67	Frostbitten feet	Arteriosclerosis, generalized; gangrene, frostbite, foot, right; amputation, leg, left, old	Right 0	Lumbar sym- pathectomy	Right	2/23/40	Improved

In the group classified as Frostbite Gangrene there were 6 patients, all male, 5 white and 1 Negro, the average age being 57.8 years. All 6 had ulceration or gangrene, of which 4 healed after sympathectomy. Two patients had had a previous amputation of one leg; the remaining leg in 1 was saved by sympathectomy. There were two legs amputated

after sympathectomy but in both these cases the sympathectomy was done to limit the extent of the gangrene and not in the expectation to save the leg. The final result showed 5 patients improved, 1 not im-  
proved, and no deaths.

TABLE IV  
VASOSPASM AND OBLITERATIVE ARTERITIS FOLLOWING EXPOSURE TO COLD

NO.	NAME	SEX	COLOR	AGE	SYMPTOMS	ADDITIONAL DIAGNOSES	PULSATION IN PEDAL ARTERIES	OPERATION	SIDE	DATE	RESULT
39	B. R.	M	B	45	Pain in both feet	Syphilis (Wassermann)	Left 0 Right +	Lumbar sym- patectomy	Left	2/17/40	Improved
49	J. S.	M	W	47	Pain in both feet	Amputation, toes, feet, bi- lateral, old; ulcer, heel, left	Left + Right +	Lumbar sym- patectomy	Left Right	10/21/39 12/ 6/39	Improved
59	W. W.	M	W	44	Pain in both feet	Amputation, toes, feet, bi- lateral, old	Left 0 Right 0	Lumbar sym- patectomy	Right	3/ 5/40	Improved
30	W. M.	M	W	59	Frostbitten feet	Hypertension; cardiovascu- lar disease; ulcer, great toe, foot, left	Left, slight Right +	Lumbar sym- patectomy	Left Right	1/ 2/39 3/29/39	Improved

The classification Vasospasm and Obliterative Arteritis Following Exposure to Cold, or Cold-sensitive Extremities, includes a group of patients who, after an exposure to a cold temperature sufficient to cause mild or severe frostbite, are rendered by that exposure always very susceptible to subsequent exposure to cold temperature. In civil patients do not have generalized peripheral vascular disease. In civil life many of these patients suffer with chronic alcoholism and have wandered about the snow and slush of streets for many hours or days between visits to taverns. In the army a great many of these people

will be found as a result of the rigors of winter fighting. The exact pathologic state of the arteries has not been described. Usually there is good pulsation in the feet, and always great spasm of the arteries can be demonstrated by test.

Four of our patients fall into this classification, 3 white males, and 1 Negro male, the average age being 48.7 years. All 4 had warm, painless extremities after operation. In none of them was there an absence of pedal pulsation even before operation, and in none was an amputation necessary.

who had suffered a leg amputation because of arteriosclerotic gangrene two years previously and whose remaining leg in which gangrene had started was certainly saved by sympathectomy. Healing also occurred (Case 25) in a man 57 years of age, in whom painful ulcers of long standing healed promptly. In Case 42, there was diabetes, arteriosclerosis, advancing gangrene of the right foot, and fever in a woman aged 46 years; following sympathectomy there was a rapid subsidence of fever and rapid healing of the foot. In Case 58, a 36-year-old man with a pulseless right foot, had for two years pain in the toes, arch, and heel of the foot, and for four months a painful ulcer of the heel which had resisted all efforts at cure. Sympathectomy brought immediate relief of all pain and rapid healing.

One leg had been amputated previously in four of our cases (Cases 1, 23, 48, and 55). By sympathectomy on the opposite side we believe that we saved the remaining leg from a similar fate. Even the presence of old age and advanced arteriosclerosis did not deter us, as in one man of 74 years (Case 48), where remarkable improvement of the remaining leg followed operation. In Cases 19, 35, 40, and 45 sympathectomy failed to save the leg.

With advanced frostbite gangrene, sympathectomy failed to save the leg, but probably limited the level of the gangrene in Cases 13 and 36. A less advanced type of frostbite gangrene was helped by sympathectomy in Cases 29, 49, and 59.

#### PAIN

The relief of various types of pain following lumbar sympathectomy has been gratifying and most instructive. In such a group of patients are found (1) the pain of intermittent claudication in the calf muscles of the leg, (2) the diffuse rest pain in a foot with or without the presence of actual ulceration, and (3) the rest pain localized in a small ulcer or in a gangrenous toe.

Twenty-four of our patients suffered with intermittent cramplike pain in the leg muscles after exercise. This type of pain is not generally supposed to be amenable to any form of therapy. Nevertheless, following operation nine patients were relieved of all pain, eight were improved, and seven were unimproved. In three of the seven patients unimproved for intermittent claudication in the calf muscles, the circulation of the foot was improved as evidenced by the rise in temperature, the improvement in color, and the cessation of pain in the foot, as in Cases 27, 34, and 43.

Dr. R. W. Wilkins and we decided that Case 41 would be a particularly favorable one from which valuable information could be obtained in this unanswered question of the possibility of operative relief in intermittent claudication. The patient was an intelligent woman 64 years of age, the wife of a retired army colonel. Her feet were cold and pulse-

TABLE VII  
IDIOPATHIC THROMBOSIS, ARTERIES, LEG

NO.	NAME	SEX	COLOR	AGE	SYMPTOMS	ADDITIONAL DIAGNOSES	PULSATION IN PEDAL ARTERIES	OPERATION	SIDE	DATE	RESULT
9	T. B.	M	W	48	Intermittent claudication	Thrombosis, arteries, leg, left	Left 0 Right +	Lumbar sympathectomy	Left	7/16/41	Improved
58	E. W.	M	W	36	Rest pain, right foot; ulcer, right heel	Thrombosis, arteries, leg, right	Left + Right 0	Lumbar sympathectomy	Right	4/26/40	Greatly improved

A separate classification was called Idiopathic Thrombosis, Arteries, Leg, to include those patients who showed no signs of generalized vascular disease, and who had one leg in vascular difficulty for some unexplained reason with the other leg normal. The first patient, a man 48 years of age, showed, after operation, improvement in the color and temperature of the leg but only slight relief to intermittent claudication. The second patient obtained immediate and dramatic relief of pain in his leg and foot with rapid healing of a long-standing ulcer.

The first patient, a man 48 years of age, showed, after operation, improvement in the color and temperature of the leg but only slight relief to intermittent claudication. The second patient obtained immediate and dramatic relief of pain in his leg and foot with rapid healing of a long-standing ulcer.



had cold pulseless feet. A man aged 57 years (Case 25) suffered severe rest pain in his right foot which made sleep impossible unless the leg hung down outside his bed. A man aged 57 years, with angina pectoris (Case 57), had been suffering with sudden severe pain in his right leg and foot over a period of two months, and even with hypodermic injections of morphia he could obtain only two hours' sleep at a time. Operation stopped all pain immediately, and he resumed an active law practice with only a modicum of his former pain.

The third type of pain encountered, that of rest pain localized in a small ulcer or in a gangrenous toe, is a circumscribed, intense pain which may or may not be associated with the pain of intermittent claudication or that of diffuse pain in the affected extremity. Four of our cases are particularly good examples of this local pain. Cases 14, 24, 25, and 58. All of these patients showed immediate relief by sympathectomy. In two women (Cases 14 and 24), aged 37 and 65 years, each with a small agonizingly painful ulcer of the leg, the pain ceased immediately and the ulcer healed rapidly following operation. A man of 36 (Case 58) showed much the same type of ulcer with the same gratifying result.

The current fallacy of not operating on patients for the relief of symptoms due to advanced arteriosclerosis has in our experience been disproved. Under the present accepted standards the majority of the patients in our group would have been considered not amenable to operative relief. However, we did operate, and a reading of the abstracts of the clinical records alone will illustrate how gratifying the results have been.

We do not wish to minimize the great importance of measures other than operative with these patients, or to maintain that such measures are not at times in themselves sufficient. The majority of our patients reached us after repeated trials with various drugs to stimulate vasodilatation, and with courses of intermittent positive and negative pressure to an extremity. Such additional aids should be continued after operation, if complete relief is not given following sympathectomy. Furthermore, an extremity, after the vasoconstrictor influence has been removed, is more susceptible than before to such treatment as that of passive vascular exercise. Of special importance with these people is the meticulous daily care given by the patient to his feet, his avoidance of injury when cutting the nails, and his avoidance of vasoconstrictor influences such as cold, mental anxiety, and tobacco.

We have included in this report patients with various complaints for which a lumbar sympathectomy was done. The clinical subdivisions have been further analyzed under the following classifications: (1) arteriosclerosis (24 cases), (2) thromboangiitis obliterans (15 cases), (3) frostbite gangrene (6 cases), (4) vasospastic extremities following old exposure to cold (4 cases), (5) varicose ulcer (4 cases), (6) obstruction



vena cava (1 case): (7) idiopathic thrombosis, arteries, leg (2 cases), (8) trophic ulcer (1 case), (9) chemical burn (1 case), (10) ununited fracture (1 case).

As stated previously, the exact pathologic classification of certain cases is clinically impossible. What is the dividing line between thromboangiitis obliterans and arteriosclerosis? Is it the age of the patient? Is it the absence of generalized sclerosis or of x-ray changes in the arteries? Should patients with diabetes and evidence of peripheral vascular damage be given a special classification?

We have included in our group of thromboangiitis obliterans those patients 50 years of age or less who complain of intermittent claudication or of rest pain, or who have had recurrent attacks of phlebitis and who show little or no pulse in the arteries of the extremities and no evidence of a generalized sclerosis of the arteries throughout the body.

The five patients with diabetes are included in our group of arteriosclerosis since their diabetes seems to represent a causative factor superimposed on their arteriosclerosis rather than a discrete entity.

The first of the operations in this series was done Jan. 2, 1939, the last on Oct. 27, 1941, a period of two years and nine months. We had planned to allow a greater postoperative interval to elapse before making this report but, since two of us (I. R. T. and W. S. C.) are on active service in foreign countries,\* it seems wisest to submit our present records for publication with the full realization that some of our patients reported as improved will subsequently have further peripheral vascular trouble. However, these patients have been given substantial relief even if for a limited period of time. Although some of the patients with thromboangiitis obliterans may have further trouble, we believe our unusually hopeful figures in this group have been due to early operation. We feel certain that we have relieved pain and saved many legs in this, and in the older, arteriosclerotic group usually regarded as hopeless, and have added a period of more comfortable living to a group of patients who have heretofore been destined to spend their remaining days in bed, in a wheel chair, and in more or less constant pain.

#### THE TECHNIQUE OF THE EXTRAPERITONEAL APPROACH FOR LUMBAR SYMPATHECTOMY

##### 1. Anesthesia.

2. An incision is made through the skin of the anterior abdominal wall parallel to the midline and 5 cm. lateral to it beginning at a level 5 cm. below the umbilicus and extending directly upward a distance of 8 cm. The upper end of this incision is then continued at an obtuse angle laterally for a distance of 4 cm. (We have tried several other incisions but this one affords better exposure and requires much less muscle retraction.)

\*The third author (W. R. M.) is entering the service at this writing.

3. The fascia and the lower fibers of the external oblique muscles are incised and retracted along their line of direction (Fig. 1).

4. The internal oblique and transversalis muscles are separated in the same way (Fig. 2). (The first assistant is more helpful standing on

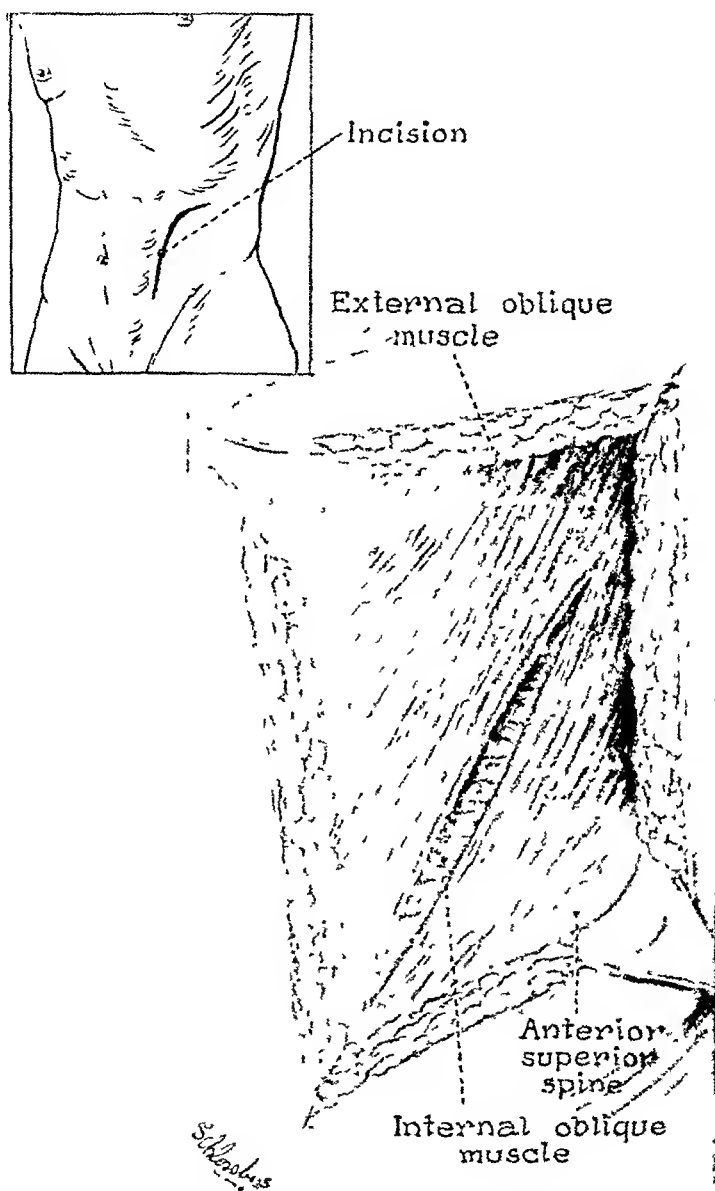


Fig. 1.

the same side of the patient as the operator, the second assistant with the retractors on the opposite side.)

5. This last step exposes the peritoneum. It is important to begin the separation between the peritoneum and the transversalis muscle laterally and not medially, and not to continue the separation too far

medially. The peritoneum is much thinner and much more closely attached to the transversalis muscle medially, and any attempt to separate them here may result in tearing through the peritoneum into the abdominal cavity (Fig. 3).

6. Separation of the peritoneum is now continued around posteriorly to the midline, great care being taken to free the peritoneum from the fat and areolar tissue over the quadratus lumborum and iliopsoas muscles.

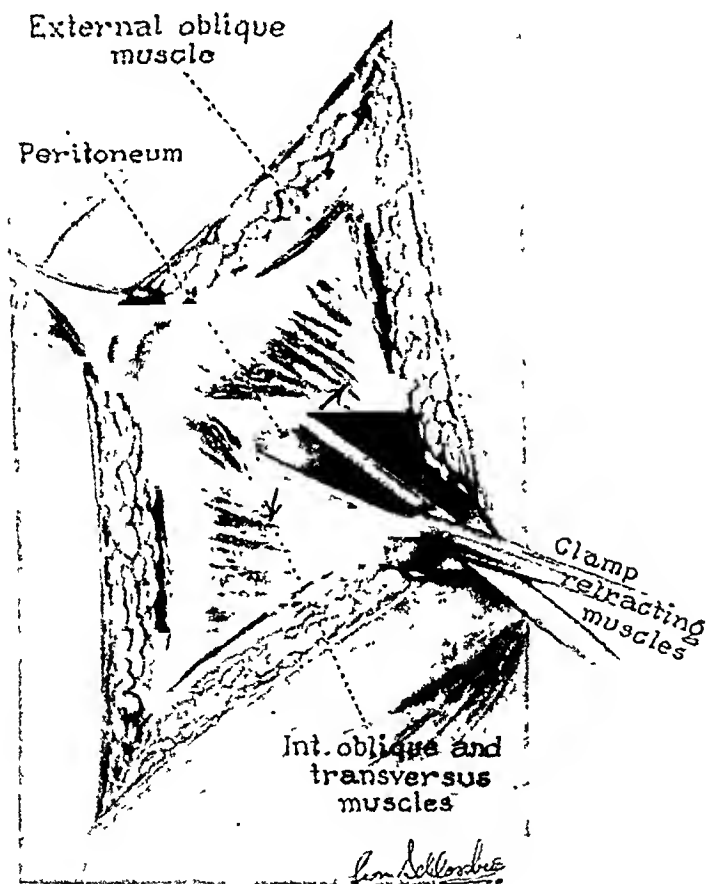


Fig. 2.

7. The sympathetic chain is next located running in its constant position against the bodies of the lumbar vertebrae and parallel to the medial border of the corresponding psoas major muscle. Location of this chain may be facilitated by palpation with the gloved finger.

8. The chain is gently retracted from its bed with a blunt hook and severed 1 cm. distal to where it crosses the brim of the true pelvis.

9. With the proximal end of the severed chain clamped and gently lifted the segment of the chain containing the second, third, fourth, and fifth lumbar ganglia is resected (Fig. 4).

10. After all bleeding points are scrupulously controlled the wound is closed in layers with fine silk.

#### FINDINGS

1. In patients suffering from peripheral arterial disease it is possible by lumbar sympathectomy to heal indolent ulcers quickly and to prevent the spread of gangrene and the necessity of amputation.

2. In a number of patients who have already had one leg amputated we have by sympathectomy been able to save the remaining leg—bringing about the difference between moderate disability and an almost helpless cripple.

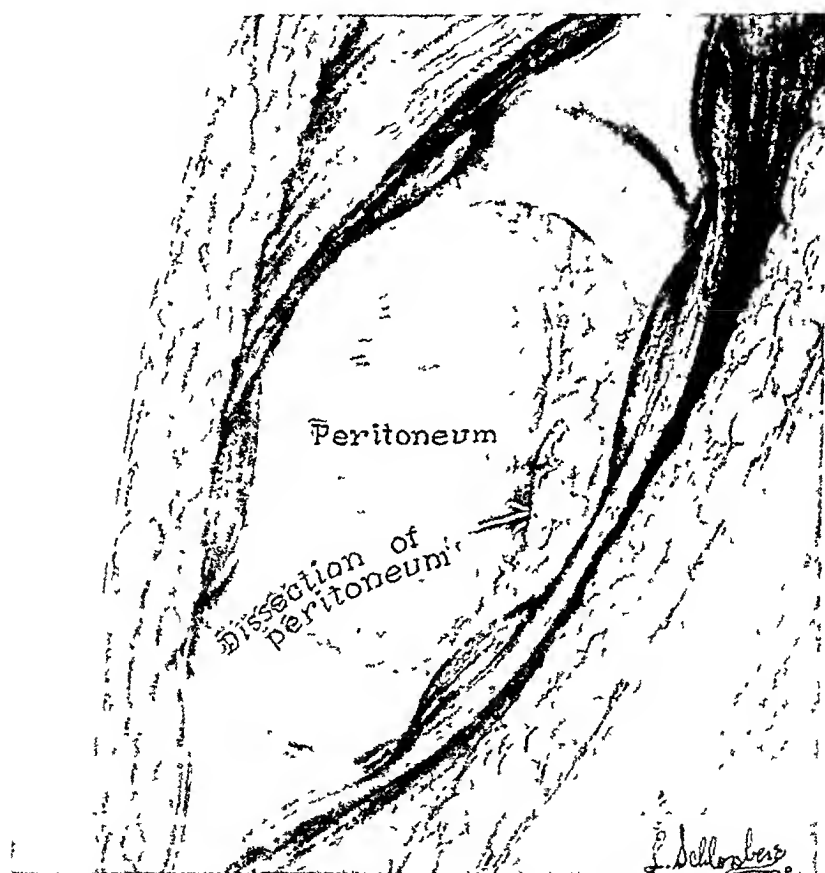


Fig 3

3. Patients threatened with serious vascular trouble in the extremities should have a prophylactic sympathectomy before a stage of ulceration develops.

4. Following operation the pain about an ulcer, pain in the toes, or pain in the feet disappears in the great majority of cases.

5. The muscular pain of intermittent claudication disappears in many patients following operation. Sometimes the patient will state that his

legs tire after walking a number of yards but that he has none of the old cramplike pain. In some patients the pain of intermittent claudication is not helped by operation, but the foot and leg on the side operated upon are made warmer and of a better color, and the danger of gangrene averted.

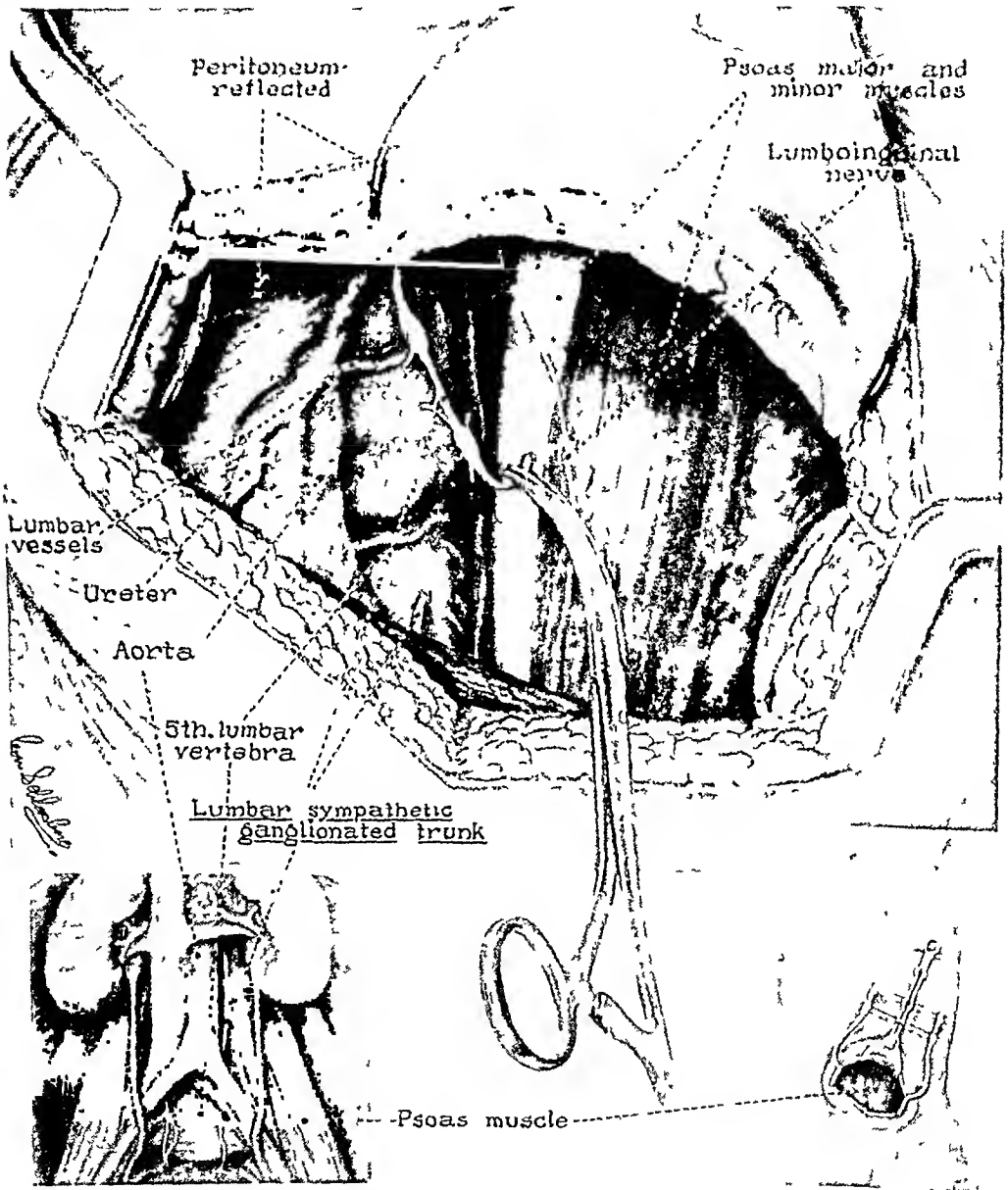


Fig 4

6. A negative response of the patient to preliminary tests should not preclude the possibility of aid through sympathectomy. In many patients, during a preliminary test by novocain sympathetic injec-

the temperature of the foot is not increased nor is the color of the affected toes improved, although the pain usually ceases. Nevertheless, following sympathectomy, there is a rise in temperature, a great improvement in color, and a cessation of pain.

7. The healing of varicose ulcers is not helped by sympathectomy until the ulcer with its surrounding avascular fibrous tissue is excised, the area grafted, and the varicose veins injected. The better circulation in the skin resulting from sympathectomy then helps prevent the recurrence of the ulcer.

8. Lumbar sympathectomy did not hasten the healing of an ulcer resulting from a chemical burn nor that of an ulcer due to alcoholic peripheral neuritis.

9. In one patient with delayed union of a fracture of the tibia and fibula new bone was formed at the site of injury six weeks after sympathectomy.

#### CONCLUSIONS

1. The association of vasomotor spasm with organic disease of blood vessels is stressed.

2. Gangrene and the threat of gangrene associated with peripheral organic disease are amenable to sympathectomy.

3. Pain in organic as well as in functional vascular disease may be relieved by sympathectomy.

4. The current fallacy of not operating on patients with advanced arteriosclerosis has been disproved.

We are especially indebted to Dr. Thomas B. Aycock, Chief of the Surgical Service of the Baltimore City Hospitals, who asked the senior author in 1939 to take charge of the patients with peripheral vascular diseases. Dr. (now Lieutenant Colonel) George H. Yeager, whom we have consulted frequently, operated on the first patient in our series. Dr. W. S. Cheney first suggested that we try lumbar sympathectomy in a large group of patients with advanced arteriosclerosis. Dr. (now Lieutenant Colonel) J. Bordley III, Dr. R. W. Wilkins, and Dr. L. W. Eichna helped us a great deal in the preliminary clinical studies of our patients. Forty-five of these patients were from the public wards, fourteen from the private. The two senior authors performed the majority of the operations, the other operators, in order of number of operations done, were Drs. R. D. Woolsey, T. A. Nestor, L. K. Woodward, S. R. Gehlert, Jr., H. L. Rigdon, W. R. Moses, E. R. Halev, R. P. Bell, Jr., G. S. Bourne, H. S. Smith, Jr., H. W. Jones and A. B. Crampton. To them we are very grateful, as well as to Drs. D. B. Hebb, B. H. Hand, and H. H. Trout, Jr., who helped with cases not included in this report during the early months of 1942. All of these men are now in the armed forces.



## Book Reviews

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**Backache and Sciatic Neuritis.** By Philip Lewin. Philadelphia, 1943, Lea & Febiger.

The author has produced a compendium of information available in the American and English literature on the subject of backache and sciatic neuritis. For this he deserves much credit. It is a big task and one which has not before been undertaken by many. There is a great need for such a book and as an encyclopedia of information on this subject the work must be considered valuable.

In any subject as controversial as backache and sciatic pain, one must expect disagreement with many things stated by any author. Perhaps for this reason Dr. Lewin has avoided any attempt to evaluate much of the information contained in the work. For one looking for means to a final diagnosis in a given case of backache the book might be disappointing. It is my feeling that in some respects the author might have been more specific along this line. Perhaps he would have subjected himself to more criticism by so doing than by following the course he has chosen.

The book is well printed and quite well illustrated with good photographs, drawings, and charts, all of which help to make clear the picture that Dr. Lewin is trying to present.

This volume is one that has been needed for a long time. While it cannot be expected that one could publish a volume on as controversial a subject as this that would be acceptable to all, it seems to me that the work is well done and will be a useful reference book to all interested in the subject of backache.

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**The Arthropathies. A Handbook of Roentgen Diagnosis.** By Alfred A. de Lorimier, A.B., M.A., M.D., Colonel, Medical Corps, United States Commandant, The Army School of Roentgenology, Memphis, Tenn.; formerly Director, Department of Roentgenology, Army Medical School, Washington, D. C. Cloth. Pp. 319, with 678 figures. Chicago, 1943, The Year Book Publishers, Inc. \$5.50.

In the field of roentgen diagnosis the atlas method of presentation has many advantages. In the past it has suffered from the inadequacy of the illustrations both in quality and quantity. In this small book this handicap has largely been overcome, and as a result a wealth of material is presented in a very small space and in a very concise manner. Both the author and the publishers are to be complimented on this achievement. The attack on the subject is unique, as the author has not been content to confine himself to joint diseases but rather has concerned himself with all diseases affecting the joints or the portions of the bones contiguous to the joints. Thus, such widely disparate lesions as congenital syphilis and bone tumors are given consideration. There are well over 600 figures, including such unusual conditions as Baker's cyst and anihum, but a detailed study of the commoner joint lesions is not neglected. Many of the illustrations are excellent in quality. Others, unfortunately, are not well reproduced. The labeling is adequate, although the conglomeration of four to six captions into one paragraph makes the study of the figures unnecessarily complex. There is such a wealth of material in this volume that it is impossible to criticize details. Certainly every physician will find this small pocket-sized book a storehouse of information about diseases of the joints and of the bones about them.

**Medical Radiographic Technique.** By Technical Service Department of General Electric X-Ray Corporation under the editorial supervision of Glenn W. Files, Director. Cloth. Pp. 365. Springfield, Charles C Thomas, Publisher. \$6.00.

The expansion of the field of roentgen diagnosis and the increasing need for well-trained x-ray technicians should make this new book on x-ray technique written by technicians particularly welcome. The section on x-ray physics is well presented. It should permit a well-grounded individual to attain a good understanding of the theories underlying x-ray technique and of the construction and utilization of the various pieces of equipment necessary for x-ray diagnosis. The description of skeletal anatomy is well selected for teaching x-ray technicians. Unfortunately the same cannot be said for the section on visceral anatomy, which is too brief and rudimentary. The photographic representations of the standard positions used for different parts of the body are excellent, but too many important procedures are omitted. It is difficult to understand why a recent text on roentgen technique would omit completely such important items as bronchography, roentgenkymography, the structure and uses of the cassette, radiography of the stomach upright, as well as other less obvious matters. The illustrations are good; especially are the photographs of the various standard positions well done. The book will be useful to anyone using x-rays for examination, but is not sufficiently complete nor well enough written to displace any of the present standard texts on this subject.

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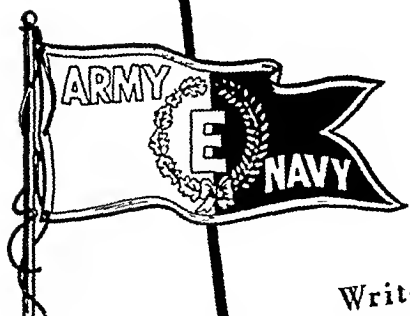
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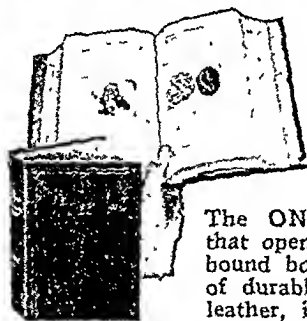
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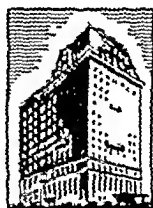
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